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FACTORY ORGANIZATION AND MANAGEMENT

By R. M. DYER, Seattle, Wash.

The word "factory" is applied to such a wide variety of establishments, varying so greatly in size, organization, number of employees, quality and quantity of output, location, conditions, etc., that definite rules in relation to factory management would be frequently so inappropriate and so inapplicable as to cause them to be dignified by the name because of the numerous exceptions only.

Whenever a number of men are brought together to accomplish a certain object the need of organization is not questioned, whether it be for amusement, profit or protection. Every man seeks the benefits of organized effort thereby admitting his need of it if weak and taking advantage of its wider opportunities if strong.

To a careful observer it is apparent that there are a number of fundamental principles—not rules—which may be applied in the development of any organization for manufacturing purposes. Such principles from their nature can be but general and should be accepted as a basis of investigation only and applied after much revision to the particular case under consideration.

A factory might be defined as being an establishment arranged and equipped for the manufacture of any article or articles, simple or complex, in nature, varying from a wooden tooth pick to a locomotive; for the formed article the plant equipment may consist of a simple jack-knife or a series of machines almost as costly and intricate as a battle ship, while

the latter may be built in a small shop capable of turning out one or two locomotives a year or on a larger scale with a capacity of a locomotive every six or eight hours.

For the purposes of this discussion a middle ground will be chosen. Owing to the rapid development of agricultural resources a large proportion of the factories of the United States are engaged in building farm and plantation machinery. Such machinery being usually developed and improved from a careful study of needs, conditions and adaptability rather than by abstract mechanical inventiveness gives to their production a uniformity in methods of production, a continuity of manufacture, and the possibility of forecasting the future in reference to disposition of products, thereby permitting a most economical organization and equipment of the manufacturing establishments not to be found in cases where exploitation or peculiar conditions of social or commercial development are required to insure the disposal of product.

Further than this, in agricultural machines such a complexity of materials, skill and method are required that the widest range of departmental segregation may be advantageously perfected in the factory intended for their manufacture. We will assume that we are to discuss the matter of factory organization as applied to an establishment having an established market and extensive line of standard machinery, which is subjected only to such changes from year to year as may be found necessary to keep abreast of public demands, with such additional elements added from year to year as mechanical ingenuity may suggest or as may be forced upon it in order to meet competition or to enter new fields.

In all cases the active force is the capital which is invested in the enterprise. This capital keeps in touch with the organization through its owner, or its board of directors.

It must be borne in mind that the sole reason for operating the factory and improving its organization is to insure a profit which will accrue to the benefit of those who permit the use of their capital and suffer the risk of an investment.

Having in view this principle it may be noted further that many elements which apparently do not lead to this end, when fully analyzed are found to have positive values, adding much to the future productiveness or stability of the institution. Of such elements might be mentioned improvement of sanitary conditions, shortening of daily working period, entertainment and recreational arrangements, establishment of special schools for workmen and their children, and various other apparently philanthropic movements all of which are promoted to increase either immediately or in the future the profits of the business.

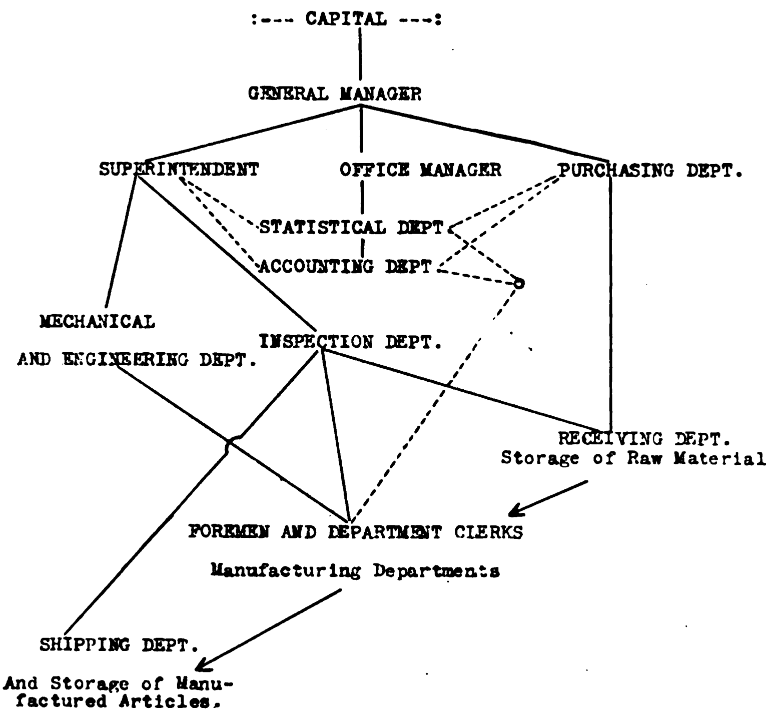
For purposes of illustration we will consider a manufacturing establishment of some magnitude large enough to profitably employ a full quota of officers, and with a product of such quantity and such diversity as to require a reasonably large number of shops and departments.

In smaller organization each man in the management might be required to perform the duties of several of the separate officers. It is noticeable, however, that the officers duties are quite as distinct whether the official functions are performed by one man, as they frequently are, in a small establishment, or by many, in establishments of considerable magnitude.

The following outline of the arrangement of departments is recommended as being both economic and forceful:

PLATE I.

Graphical Illustration of the Relations of Factory Officials and Departments.



The duty of the general manager is to interpret the wishes of the owner or board of directors into working form; that is, to issue such orders to the heads of various departments as will cause the operation of the factory to be conducted upon the plan which is desired or which he may devise himself, being usually a man of broad experience and of good judgment it is usually delegated him to develop such plans.

Two chief assistants of ability in their line are his councilors and receive from him such general orders as his policy may direct, they in turn reduce and subdivide such orders into suitable form and transmit them to their subordinates.

An intermediate department the "Accounting and Statistical" receives and transmits information for both Supt. and sales Dept. and also furnishes such information to the general manager as may be needed by him. The purchasing department should be made supplemental to the general manager only and to it such statistical data is transmitted as may be needed to secure without failure a proper stock of raw material and such goods from other manufacturers as may be needed to complete shipments.

The superintendent is the directing force of the factory through the foremen by means of his orders for goods to be manufactured justifying data having been furnished by the statistical branch of the office.

The inspection department has no authority to direct operations but "inspect and report" to the superintendent quality of purchased and manufactured goods and on perfection of the detail work in the general departments.

The master mechanic is the chief lieutenant of the superintendent; under him is placed the designing of all tools and special machines needed in the several manufacturing departments, the designing, pattern-making, power and machinery equipment, full protection, and the design and development of trial machines, which after being perfected are turned over to the factory for duplicate production.

The economic results of doing each class of work in a shop especially arranged for it, and the advantages gained by grouping workmen of the same or similar trades and grade together, under a foreman who is a thorough master of the trade, leads to the development of departments in which both equipment and organization may be used in its most productive and therefore most profitable capacity.

The manufacturing departments consist essentially of the following:

Foundry, Forging, Machining, Woodworking, Finishing, Galvanizing, Turning and Enamelling and Assembling.

Each of these are frequently subdivided; for example, a separate brass foundry may be required, a separate machine shop for brass working, and further separation of the machine work into heavy and light, rough and finished. Some factories require such a large amount of bolts that a separate forging shop is established for their manufacture and a separate machine shop for threading and finishing them. A single foreman may be able to direct and make all the records in a small shop, while in a large department several assistant foremen and clerks may be required.

Having thus outlined the forces of the organization, a few notes on their relation and duties, may serve to assist an investigator who may be studying a particular case with the view of revising or improving an existing organization or in developing a new one.

For example, we will select a single machine that is to be manufactured. The machine is thoroughly studied by the master mechanic or his assistants. The operations on each individual part of the machine are outlined and a factory routine is made out for each part showing the various departments through which it must pass. A set of samples is then furnished to each department covering the work which that department is to perform and illustrating the work to be done on such parts both in that department and in other shops or departments through which the part may have previously passed.

All the special tools, templates, etc., should be designed and built in the tool-making department for performing the necessary operations on each and furnished to each of the several departments. The work of each department should be studied by the foreman thereof under the direction of the master mechanic to ascertain if the equipment of the shop is sufficient to handle the anticipated quantities of the parts to be manufactured, without interfering with its capacity in relation to established lines of work.

A complete schedule of prices to be paid for the work should be made out if the shop is operating under the piece work plan, or if the shop is run on the rate per hour or rate per day plan the amount of each particular operation which is to be considered a day's work must be established. Such pricing or rate-fixing can usually be best done by one of the master mechanics' assistants who has made such work a special study.

The inspectors in the various departments should be thoroughly drilled in the construction of the machine and the points wherein variation from design would either increase cost or decrease the efficiency of the machine.

A factory statistical department which is up-to-date will readily tabulate on a single sheet of record paper each of the schedules relating to tools, process, drawings, inspection, piece-work, price, cost and routing and sample factory orders, when such schedules are made in duplicate on sheets of uniform size, one complete set should be bound together for reference and the other copies should be distributed to the other binders of similar kind, that each clerk may be supplied with a binder containing all schedules which relate to his particular work in the organization.

When the above preliminary work is carried out, the shop organization, management and equipment are ready to begin the work of manufacture.

Orders may be issued on the various departments for the single or combined elements of the machine to be manufactured in such quantities as may be desired.

The main feature to be observed is that no matter how many articles are to be manufactured or of how many intricate detail parts each article is composed, or how many detail operations each detail part must go through before it is ready for its proper function in the assembled machine, the entire work must be scheduled and classified so that each element or detail part will undergo its proper transformation without delay and appear in proper quantities at desired intervals and at a cost not exceeding the estimate.

The accounting, statistical and designing departments must work together on a well devised plan, to bring about the desired result. Data must be furnished to the various heads of departments through proper channels to enable the perfected article to be manufactured of the desired quality, in the desired quantity, and for delivery at the proper time.

Methods of factory accounting are of many kinds, card record system, loose leaf record system and a large number of modern counting-house conveniences that help to simplify and enhance the value of factory accounts, but each organization will probably need a system different in great or less degree from that of any other. It behooves the organizer therefore to be widely informed in such matters and wholly unprejudiced in their application.

Other questions of organization can only be hinted at in this paper. The handling of labor questions in times when strikes and similar labor disorders threaten, can only be well done when wisely done.

The organizer of a large industry may lay his only hope of avoiding or settling labor difficulties in his ability to be absolutely fair and absolutely square both to owner and operator.

A reputation for this quality won in times of labor peace may prove the best equipment in times of labor war. A clear and distinct separation and definition of the duties of the various lieutenants, such as heads of departments, assistants, clerks, etc., will prove helpful in preventing personal and petty quarrels, insignificant at times, but always hurtful to the organization.

An efficient and able purchasing department is most desirable, as the purchase of supplies in large quantities on the constantly varying market is speculative to some degree and should be entrusted only to able men. The ability to purchase supplies at the right time, and in the right quantity, adds a large element of profit to the work of the organization.

The preservation of the plant and equipment against destruction by fire, the protection of operatives by proper safeguards, are also important factors of successful management.

The ability to observe and grasp the detail of a large manufacturng establishment, to plan and execute a systematic method of operation, to select men who can and will be faithful and forceful, and to delegate to properly selected men such details of management and operation which would otherwise overwhelm him, able as he may be, marks the manufacturing engineer, the captain of industry, on whose shoulders falls the task of organization and operation of a manufacturing establishment.

A METHOD OF DESIGNING TRANSFORMERS

By FRED A. FISH, Ames, Iowa

Probably the alternating current transformer is the simplest of all electrical machines to design; but, even so, the number of trial designs and tentative assumptions that must be made before a satisfactory result is obtained makes the process more or less tedious. The method which is presented here is intended to make this "cut and try" process more certain in its results and thus to reduce the amount of it. It is not to be understood that no assumptions are to be made, or that the method is based only upon theoretical considerations; on the other hand, the number of assumptions made are no less than usual and, in fact the success of the method depends largely upon the knowledge and experience of the designer as to the proportions, flux densities, etc., which have been found to be most successful in actual practice. It is in the manner of applying this data to the design and calculation of transformers, that the method differs from the usual procedure. It is applied herein

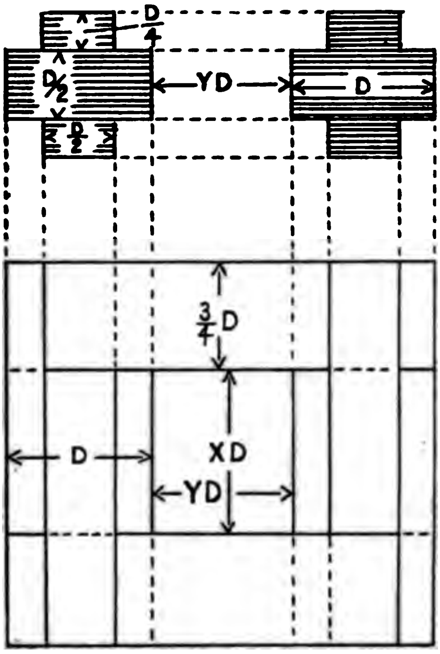


FIG. 1 CORE TYPE

Y = 8 TO 2 : X = 1 TO 5

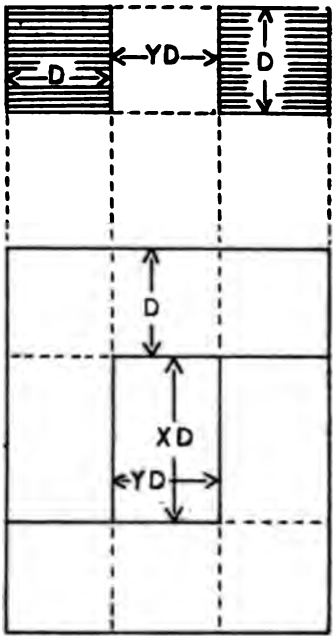


FIG. 2 CORE TYPE

Y = 8 TO 2 : X = 1 TO 5

to the two most common forms, the core type and the shell type. Figures 1, 2, 3 and 4 illustrate these shapes and in connections with the figures are given the various dimensions in terms of the width (d) of the core. The ratios of these dimensions to d are in terms of arbitary constants and the values given represent the limits found in average practice.

The values of K_1, K_2 and K_3 given later depend, of course, not only upon x, y and v, but also upon the shape of the stampings and upon the form given to the cross-section of the core. The values given below apply only to the shapes and forms shown by the figures and also include the assumption that but 90% of the total space occupied by the stampings is iron.

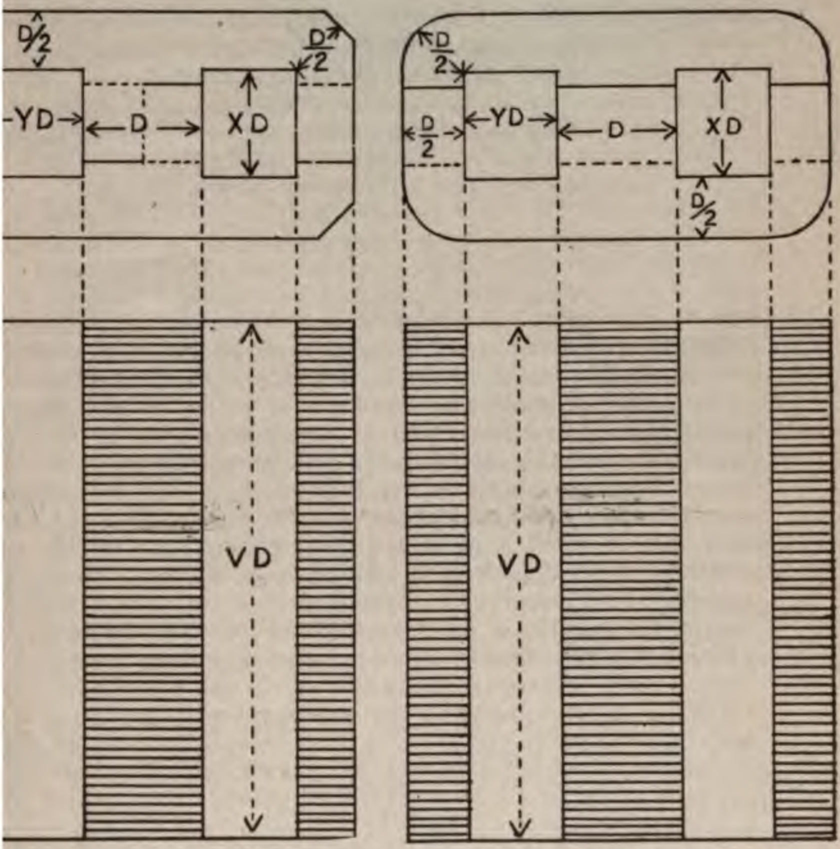
TRANSFORMER DESIGN.

For generalization, it may be observed that the volume of iron is a function of d^3, and may be put

$$V = K_1 d^3 \qquad (1)$$

where $K_1 = .45\,(3x + 3y + 5.25)$ for core type, Fig. 1.

$= 1.8\,(x + y + 2)$ for core type, Fig. 2.



IG. 3. SHELL TYPE FIG. 4 SHELL TYPE

O 1.5; X=1 TO 3; V=2 TO 6 Y=.5 TO 1.5; X=1 TO 3; V=2 TO 6

$=1.8v(x+y+.91)$ for shell type, Fig. 3.
$=1.8v(x+y+.89)$ for shell type, Fig. 4.

Also the area of the magnetic circuit varies with d^2 and nay be put

$A=K_2d^2$

where $K_2=.675$ for core type, Fig. 1.
$=.9$ for core type, Fig. 2.
$=.9v$ for shell type, Figs. 3 and 4.

Again, the average length of a turn varies as d and may be put

$lt=K_3d$

where $K_3 = .85y + 3.5$ for secondary turn, core type, Fig. 1
$= 2.4y + 3.2$ for primary turn, core type, Fig. 1
$= 1.62y + 3.38$ for either prim. or sec. if sandwiched Fig. 1
$= .8y + 4.2$ for secondary turn, core type, Fig. 2
$= 2.y + 4.2$ for primary turn, core type, Fig. 2.
$= 1.4y + 4.2$ for either prim. or sec. if sandwiched, Fig. 2
$= 2v + 3y + 3$ for either prim. or sec. shell type, Figs. 3 and 4

In proceeding to design, it is assumed that the kilowatt capacity, the primary and secondary voltages and the frequency are specified. Further than this, the regulation or the efficiency, or both may be specified. Inasmuch as the percentage regulation (ignoring leakage drop) is the same as the percentage copper loss and the efficiency depends upon the amount of iron loss as well as copper loss, the basis of the design will depend upon whether good regulation or good all-day efficiency (low iron loss) is more important. For lighting transformers the former is generally specified and, while in all cases the all-day efficiency is important, in certain cases it becomes especially so and the regulation may be sacrificed in some measure. In general it would seem to be more rational to design the transformer for a prescribed regulation and if the iron loss of the resulting design is larger than can be allowed and it is not found practicable to reduce it by other means, to re-design with a slightly increased allowance for regulation. However, the design may be based on a prescribed amount of iron loss, the procedure for which will be described later.

The basis of the present method of design lies in the condition that the winding space or "window" of the transformer must be equal to the cross-sectional area of the copper plus insulation and clearance. The former is equal to $x\,y\,d^2$, as will be seen from the figures. A suitable value of circular mills per ampere (g) being chosen (which may be from 1000 to 20000) the area of the secondary conductor will be equal to $g''I''$; the primary conductor will have an area of $g'I'$; and the total copper area will be $(g''I''t'' + g'I't')$, where t' and t'' are the number of primary and secondary turns respectively. In shell transformers, where the coils are sandwiched side by side, g' will generally be the same as g''; in core type transformers where the primary coil is usually wound over the secondary and thus more easily radiates its heat, g'' may be larger than g'. In either case, let a' and a'' be the area in circular mils of one conductor in primary and secondary re-

spectively; then since $t'=Kt''$, where K is the ratio of transformation, we may write the above expression as $t''(a''+Ka')$. If this expression is divided by the space factor (s), (s is the ratio of total copper area (in square inches) to the total winding space) we have the area of the window and we may write:

$$x\ y\ d^2 = \frac{t''(a''+Ka')\ .7854}{s \times 10^6} \text{ (in square inches)} \qquad (4)$$

In a 40 K.W. transformer, s will probably average about .50 if round wire is used and .60 if rectangular wire is used, allowing 1-4″ between core and coils and 1-4″ between primary and secondary coils, besides the double or triple cotton covering of the wire and a layer of insulation perhaps 20 mils thick between layers of wire. In this connection it is to be noted that considerable space is saved by the use of rectangular wire. It should also be noted that the space factor will increase for larger sizes of transformers, for larger values of circular mils per ampere, and for a decreasing number of subdivisions of the coils. For small transformers (say 5 K.W) it may reach as low a value as .30, while for larger ones (say 50 K.W.) it may be as high as .65. The value of the voltage will of course also affect the factor, higher voltages requiring more insulation; the above figures refer to transformers for voltages from 1000 to 2000 on the primary and 100 and 200 on the secondary.

As heretofore stated the design may be worked out for a specified regulation or for a specified iron loss. We will first take up the former condition. It is usual and justifiable in the design of a transformer to assume that the load is to be non-inductive and that the drop in voltage is all represented by $e=2\,R''\,I''$ (i. e. resistance drop). The effect of leakage is very small on non-inductive loads but if it is desired to make some allowance for it, the value of e used in designing may be taken slightly smaller than the total drop to be allowed. The expression $2\,R''\,I''$ for the drop is based on the assumption that g, the circular mills per ampere, is the same in primary as in secondary and that the length of primary turn is the same as of a secondary turn. Under such circumstances, $e=\frac{R'\,I'}{K}+R''\,I''$, and $R'=K^2R''$; also, neglecting exciting current, $I'=\frac{I''}{K}$; therefore $e=R''\,I''+R''\,I''=2\,R''\,I''$.

If the primary is wound over the secondary, as usual in the

core type, the length of the primary turn is greater than that of a secondary turn and also a greater current density may be used in the primary; in such a case, the value of e used in the design should be made smaller than is to be allowed, and when the design is completed the actual value should be calculated. A fair value to use would probably be .8 or .9 of the specified value, the larger decimal being used for larger transformers, since the length of the coil will increase as compared with its depth as the size of the transformer increases.

Assuming a temperature of about 60° C for convenience, the resistance of copper per mil-foot may be taken as 12. Then

$$e = 2\,R''I'' = 2I''\,\frac{12\,l''}{a''},$$

where l" is in feet and a" is in circular mils. The length of a turn being expressed in inches,

$$l'' = \frac{l''_t\,t''}{12}.$$

$$\text{Therefore, } e = \frac{2\,I''}{a''}\,l''_t\,t'' = \frac{2\,l''_t\,t''}{g''}$$

$$\text{But } l''_t = K_3 d\text{; therefore, } e = \frac{2\,K_3 d\,t''}{g''}$$

$$\text{and } d = \frac{g''e}{2\,K_3 t''} \text{ (in inches)} \qquad (5)$$

$$d^2 = \left(\frac{g''e}{2\,K_3}\right)^2 \times \frac{1}{t''^2}$$

Substituting this value of d^2 in equation (4) and solving for t", we obtain,

$$t'' = \sqrt[3]{\frac{s\,x\,y\left(\frac{g\,e}{2K_3}\right)^2 10^6}{(a'' + Ka')\,.7854}}$$

The value of t" being obtained and substituted in equation (5) we find the value of d.

At this point in the process, a trial sketch should be made and a calculation made to determine more nearly the exact value of s, and if it is found to be far different from that assumed, t" and d should be recalculated.

Up to this time, no mention has been made of the magnetic density in the iron. It will generally be found that if the values

of the constants x, y, v, g and s are chosen within the limits usual in good practice, the value of B will come out within satisfactory limits. To test this, the fundamental equation for the induced E.M.F. is used; this is,

$$\begin{aligned} E'' &= 4.45\ f\ t''\ N \times 10^{-8} \\ &= 4.45\ f\ t''\ BA \times 10^{-8} \\ &= 4.45\ f\ t''\ BK_2 d^2 \times 10^{-8} \qquad (7) \end{aligned}$$

where A is the area of the magnetic circuit ($= K_3 d^2$) in square inches, and f is the frequency; this reduces to

$$B = \frac{3.48 \times 10^{9} \times E''}{K_3 d^2\ t''\ f}$$

The value of E″ to be used should be the induced E.M.F.; this is, with sufficient accuracy, equal to the secondary terminal E.M.F. plus 1-2 e.

For a frequency of 125, B is generally from 3000 to 5000; for f = 60, B ranges from 5000 to 8000; for f = 25, it will range from 7000 to 10000 or even higher.

However, if the value of B comes out not far from these limits, a readjustment of the design need not be made unless the iron loss is found to have an unsatisfactory value. The hysteresis loss is equal to 16.4 H f $B^{1.6}$V, where H is the hysteretic constant of iron which varies from 15×10^{-11} to 25×10 and V is the volume of iron in cubic inches. The eddy current loss is equal to 16.4 $(f\ B\ m)^2 \times 10^{-16}$ where m is the thickness of the stampings in mils and varies from 12 to 20, but most makers use 14 mils. The total iron loss is then,

$$W_i = (H\ f\ B^{1.6} + (f\ B\ m)^2 \times 10^{-16})\ 16.4\ V.$$

If this value comes out too large, B must be decreased and this may be done by increasing the value of x in equation 6, thus increasing t″. Or, if x is already as large as seems desirable, y or g may be increased, remembering that increasing y increases K_3 and increasing g increases a″ and a′.

All the above matters being adjusted, the actual resistances of the windings may be calculated and the regulation and efficiency determined. If found unsatisfactory, it will not be difficult to decide what changes may be made to improve the results.

The following table gives the maximum values of regulation and efficiency, that may generally be expected of 60 cycle transformers without unduly increasing their weight and cost. For lower frequencies, results are not likely to be so good, while for higher frequencies they should be better.

K.W. Capacity	Regulation.	Efficiency.
1	2.7	94.5
2	2.3	95.75
5	2.1	96.5
7 1-2	2.0	96.8
10	1.9	97.0
15	1.85	97.25
20	1.8	97.5
25	1.7	97.6
30	1.6	97.8
50	1.5	98.0

In case it should be desired to design the transformer from a prescribed iron loss as a basis, it will be seen that, the density being assumed, the volume of iron may be found from equation (9) and thence d from equation (1) and t″ from equation (7). in this case a calculation will have to be made to see if the space factor is satisfactory; this may be done conveniently by solving for s in equation (4), and if found too large or too small, the value of one or more of the arbitrary constants may be changed and the calculations repeated until a suitable space factor is secured. Following this, the length of windings, resistances, regulation and efficiency are to be calculated as already indicated.

It should be noted that in either method of design, the calculated values of d and t are not likely to come out as round or whole numbers. In such cases the nearest convenient round or whole number should be used and in all subsequent calculations, these actual values should be used.

It may be observed that no account has been taken of the probable temperature rise of the transformer. This is because of the fact, as stated in the opening paragraph, that the calculation of the dimensions of the transformer is based upon data taken from actual successful transformers; and if the designer keeps within such limits, the rise of temperature is not likely to be excessive. As a check on this point, however, it may be stated that if the radiating surface of the core and coils is not less than five (5) square inches per watt lost, the rise of temperature with the case on should not be expected to exceed 50° C.

It should not be forgotten that, from a commercial viewpoint, the question of weight and cost are of great importance. It is therefore quite desirable that several designs be calculated, using different values for the arbitrary constants, and that one selected which meets the specifications with the smallest weight

and cost. However, the lightest transformer may not be the least expensive, on account of the difference in the price per pound of iron and copper. Generally the cost will be the deciding criterion.

THE ELECTRICAL TESTING LABORATORIES OF THE IOWA STATE COLLEGE

By L. B. SPINNEY, Ames, Iowa

Appreciating the fact that there is great need in Iowa of a testing laboratory, at which reliable tests of electrical apparatus may be had at reasonable cost, the Department of Electrical Engineering has undertaken to establish and maintain in connection with its laboratories for instruction work an equipment in standardizing and testing apparatus which shall be available for such purposes.

Up to the present time the greatest demand has been for

Fig. 1

lamp-testing work and a special effort has been made to provide for tests of this character.

The lamp-testing equipment consists of photometers, electrical measuring instruments, standard incandescent lamps for use as working standards and a storage battery for supplying a constant electromotive force.

The principle photometers are a standard Reichsanstalt three-meter photometer bench graduated to millimeters and equipped with a Lummer-Brodhun screen and an appliance for rotating the lamp under test, (Figure 1 shows this instrument without the rotating attachment), and a Matthews Integrating photometer, Figure 2, which is used for mean-spherical-candle-power measurements.

This latter device consists esentially of a series of eleven pairs of mirrors disposed at various angles about the lamp, which is being tested, in such manner as to throw upon the photometer screen a quantity of light which is proportional to its mean spherical candle power. In order to obtain the mean spherical candle power of a lamp it is only necessary to balance this illumination of the screen by means of light from a source of known candle power, as in the ordinary methods of photometry.

The study of mean spherical candle power which are made possible by this apparatus promise to be of great interest and importance since it is believed that in the not far distant future incandescent lamps will be rated on the basis of mean spherical candle power instead of mean horizontal candle power which is customary at the present time.

This apparatus also lends itself very readily to the measurement of the mean horizontal candle power and the candle power in various directions above and below the horizontal. Measurements of this character are made by covering all but the horizontal pairs of mirrors and by tipping the lamp into the positions desired. In these tests as well as in mean spherical candle power measurements the lamp is caused to rotate while it is being tested. The use of the photometer in this way enables the study of the distribution of light from an incandescent lamp and a determination of the various effects of shades, reflectors, etc.

This photometer is regarded as a very valuable part of the lamp testing equipment, not only because of its wide range of usefulness but because it makes possible for ordinary test purposes mean-spherical and other measurements which would be practically impossible without it. Ordinary methods for mean-spherical measurements involve long and tedious labor

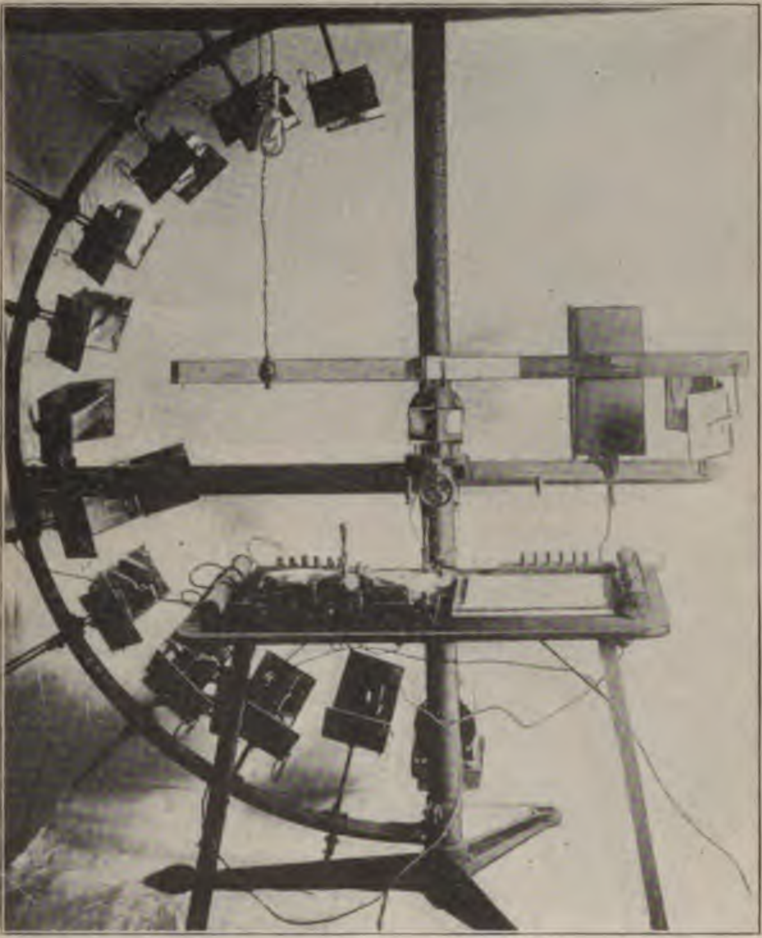


Fig. 2

and are therefore expensive and, except for special purposes, altogether impracticable. By means of the Matthews integrating photometer mean-sphecial measurements and mean-horizontal measurements are made with equal facility, and with but small expenditure of time and labor lamps may be compared with respect to their mean spherical as well as their mean horizontal effects.

For use in the photometric work there have been provided 15 standard incandescent lamps, ranging from 4 candle power to 32 candle power. The majority of these were obtained

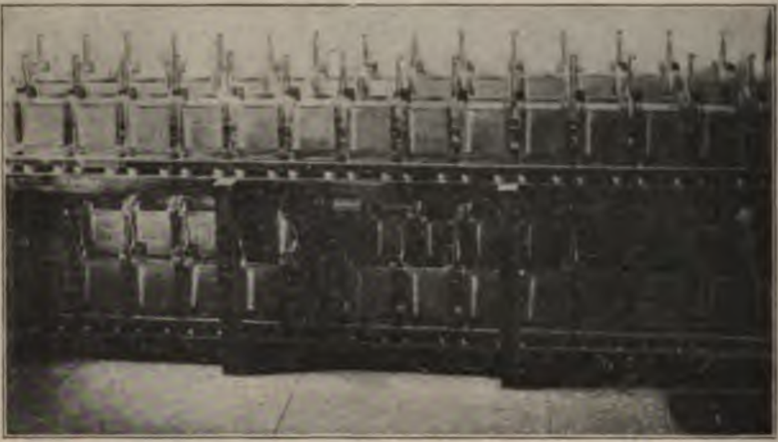


Fig. 3

Fig. 4

Fig. 5

from the Electrical Testing Laboratories and are accompanied by certificates of seasoning standardization. These lamps are used as secondary standards for all incandescent lamp tests.

In addition to these secondary standards there are primary standards which may be used for check purposes and special tests.

The equipment in measuring instruments consists of a semi-portable Weston Laboratory Standard Voltmeter having three scales, a Kelvin Multicellular Electrostatic Voltmeter which is used for checking work and measurements on alternating current circuits and Weston ammeters of suitable range for measuring the current consumed by the lamps tested. The storage battery which is used as a source of electromotive force in the lamp testing work is a battery of 60 chloride accumu-

lators of 120 ampere hour capacity mounted in glass jars. This battery is used for the initial candle power and wattage tests referred to above and for certain of the life tests described below. A general view of the battery is given in Figure 3.

Provision is also made for making life tests of lamps. For this purpose there is provided a lamp rack fitted with suitable sockets, and rheostats for adjusting the voltage. An integrating wattmeter is used for measuring the total energy supplied to the lamps under test and a recording voltmeter for indicating any possible variations which may take place in the voltage.

Standards are also provided for checking and calibrating ammeters, voltmeters and wattmeters and for the accurate measurement of resistances. The standardizing table and some of the standard measuring instruments including voltmeters, milliameter with shunts, standards of resistance, standard Clark cells and a standard Wheatstone's bridge are shown in Figure 4.

Figure 5 is a view of the storage racks showing a portion of the lamps now on hand which have been sent in from various parts of the state and from other states for testing.

At the present time tests are being made for the people of the state at the rate of $1.00 per dozen or fraction of a dozen for initial candle power and wattage tests of incandescent lamps. Other tests are made at corresponding rates. It is proposed in all of this testing work to make the charges as reasonable as is consistent with its actual cost.

THE MANUFACTURE OF CEMENT FENCE POSTS

By H. A. LAW, Lake City, Iowa

The great and growing scarcity of suitable timber, for the purpose and the consequent high prices, for the merest makeshifts, have caused the demand for a more durable and lasting fence post than the customary wood post. To answer this demand, many brains of inventors have been laboring. Steel posts, iron posts, cut stone posts, and finally concrete or artificial stone posts have been put out to fill the long felt want. Of all these, the concrete posts are the best and most pdactical for reasons of cost and durability as well as the fact that no large machinery is needed in their making. Concrete posts can be made nearly everywhere and the materials of which they are composed are of the cheapest sorts. Sand and gravel are generally had at a cost that hardly enters into the cost of production, while cement, labor and reinforcement have been

the items that raise the price of production. Cement is now easily obtained and comparatively low in price, while the labor soon becomes skilled in the making of the posts and produces them at the least factory burden. The great question, then, is reinforcement. To obtain a strong post, one must use some method of reinforcing. Inventors have strugled with the problem long and the ideas and methods that have been advanced are many and varied. The materials used to reinforce concrete fence posts run from wooden sticks to steel rods and pieces of gas pipe. The wooden sticks are objectionable because they do not furnish enough strength and because they swell and rot in the post. The gas pipe is far too expensive for practical use and cannot be considered for commercial work on that account. In a middle, western city, last year, a manufacturer was even trying to make a successful post with a tin pipe in the center.

After all experiments and ventures have been tried, it is now a known fact that the best and cheapest reinforcement is the best materials used in their strongest way. The reinforcement is obtained from the well known principle and scientific fact that steel in tension and concrete in compression are the best materials used in their strongest way. The reinforcement being decided upon, the next step is the position of this and the method of making the post.

The best place to have the reinforcement is in the corners o fthe post. This, because the greatest strength is obtained by so placing and the nearer to the edge they can be placed, without danger of the concrete breaking out under the strain, the better. I have found that in an ordinary line post the wires should be placed within a half inch of the edges. In placing one wire in each corner of the post, two wires in tension are always secured not matter in what direction the strain is placed and, of course, the twister wires prevent shearing, which is common in faulty re-enforced construction.

The next consideration is the method or process of making the concrete. I can say that the tamped or dry process has never been successful in posts when opposed to the wet process product. The latter uses less cement, makes a denser post and gives the cement enough water to make nearly perfect crystallization, at the time when it needs it, and not after the initial set has taken place. The tamped post is more subject to the action of the elements, and water penterating it readily makes it an excellent prey for the ravages of the frost. The wet process post has a glaze on the surface that makes it nearly impervious. Furthermore, there can be no accurate placing of the reinforcing wires with the tamped post, for the reason that the

tamper will displace the wire, and the concrete will not form around and unite with the wire, sinking into the shoulder of the twist and not allowing the wire to stretch as it will when wet enough to pour. All in all, I believe that the only successful way to make a fence post is to pour it.

The concrete for the post should have plenty of gravel in it, thus using less cement and securing a stronger post. It can be made five parts of gravel and sand to one of cement, or even six to one, but it is preferable to make it four to one. The dry materials should be thoroughly and carefully mixed, and then the slush should be turned many times.

Before proceeding further, it may be well to discuss fasteners for the fence wires. Many inventors and experimenters, with concrete posts, have lost sight of the fact that the posts are useless to the farmer unless fencing can be readily and easily fastened to it. All fasteners where the post is bound solidly to the wires are failures, partially because they are putting a very severe strain upon the posts and partially because straining the fence fabric. Manufacturers of woven fencing, which is the principal fencing used today, always direct that the staple in the wooden post is not to be struck the last blow, that is that the fencing is to be left free to expand and contract with the change in temperature without being bound to the posts. Therefore, pieces of wire embedded in the post to be twisted about the fence wire, or holes through the post in which wires are to be run and twist about the fence, or two projecting wires to be twisted about the fabric are not successful and will not secure the endorsement of the fence man. It has been found that two staples set parallel, and horizontally, to allow the fence wire to pass between them, and having a short key wire between them, leaving fence, although perfectly fastened to the post, free to expand and contract, are the best fasteners. These staples made of heavy wire, thoroughly galvanized, will last indefinitely in the opinion of wire experts.

The molds for the posts should be made of wood with metal ends. These molds should be in five parts, that is, two sides, bottom and two ends, and not fastened together. The face of the post should be in the bottom of the mold and the places for the fasteners should be sunken in the surface of the bottom of the mold, thus making all posts uniform as regards the placing of the fasteners. Iron molds are far too heavy and expensive to be practical, while wooden molds are light and with care will last a long time, though when they are used up they are cheaply replaced. It is preferable to have strips of molding in the molds to make the posts without a sharp edge, which is easily chipped off. The line post molds should be at

least large enough to make a post 3x3 inches top, 4x4 inches base and six and one-half feet long. The corner should be 5x5 inches top, 6x6 inches base and eight feet long and have lugs to place the brace posts under. These brace posts should be 4x4 inches and eight feet long and next to the corner a heavy intermediate post is advisable.

The posts being molded and set are ready for the curing, which should be done in the manner of other concrete products, keeping them well sprinkled. The posts can be used in thirty or even twenty days after they are made, but it is advisable to keep them at leastsixty day's previous to setting out.

The posts, being made of true concrete, during exposure to the weather, grow constantly harder and better. I have observed posts that have been allowed to freeze in a river and thaw out that apparently were as strong or stronger than before. The farmers of today are alive to every meritorious article, they read their farm journals carefully, and they are aware of the fact that there are some posts better than wooden ones. They have the money to invest in a post that offers durability and they are willing to invest it. The field for making the posts is unilmited and the demands are immense. To fence the United States farm lands, properly, would require the enormous number of over three and one-half billions of fence posts. The possibilities of the business are simply enormous. The consumption of fence posts in this country today touches so high a figure as to stagger the mind. A conservative estimate shows that the number of fence posts in use at the present time in the United States is 3,446,345,528.

In the manufacture of fence posts, the field is not hampered. The person who makes the best posts within his circle of business influence is the person who gets the enormous business.

STANDARD SIDEWALK SPECIFICATIONS

By W. D. FAUS, West Liberty, Iowa

The subject of "Standard Sidewalk Specifications" is a very important one, and one that I do not feel able to do justice in presenting a paper, as I would be a great deal more at home in the actual work of building the walk, than I am in writing a paper on the subject.

However, as I can see the great importance of having some steps taken to protect the sidewalk industry against a class of people who care nothing for their own reputation, nor for the welfare of their customers, I have condescended to do the best thing I can to give a few remarks on this subject.

It is a very important thing to have a Standard Sidewalk Specification, and it should be adopted by every City and Town where there are any cement walks being built and have some City Official of each Town to see that they are carried out, as this would be a great protection to the public who are paying for the walk, as well as the builder who wants to put down a good walk, and give his customers a satisfactory job.

It has been my experience, and I think the experience of every sidewalk builder who has been in the business for th last ten years, that it makes no difference where he is putting in walks, as soon as you get a town started to building cement walks, there are always a class of men who have nothing more than they can pack in a telescope and go at any time, who will come along and make prices to put down walk for less than the material will cost for a substantial walk, and they get lots of work, and in order to make wages must slight both labor and material, and consequently the job is not satisfactory, while it may look all right at first, but when it has gone through a winter is when it begins to show how the man could do the work at the price he did.

Such work as this is a detriment to every man in the sidewalk business, as the more poor walks there are laid the less confidence people have in cement walks, as well as in the people who are building them.

One instance I call to mind at this time illustrates a point I want to make. Last year a certain Company called for bids on a job of cement walk, and did not submit any specifications as a basis on which to bid, thus leaving every bidder to his own judgment as to the quality of the walk he would put in. The bids ranged from 6c to 15c per sq. ft. The result was, the Company rejected all bids. They then submitted a set of specifications as a basis for bidding, and the contract was let at 12 1-2c per sq. ft. However, some of the former bidders did not bid when they had to bid on specifications, and when asked why they did not bid, gave as their reason, that there would be an inspector on the job and no chance to make anything, or to come out plain, there would be no opportunity to steal enough to make a profit at the price they supposed they would have to do the work for in order to get it. This is a fair sample of the sidewalk contractor's experience all over the country, where if there was a Standard Sidewalk Specification, which if adopted by every town, and some official to make it his business to see that the specifications were carried out, it would give every contractor an equal footing, and do away with a great deal of the poor walks, as well as protect sidewalk builders against that class of competition who care only to get the work done and

get their money, and after getting it do not care whether the walk stands or not.

The men who are putting down first class walks do not fear competition if they know their competitors are responsible and have the reputation of doing good work; but when a man has to bid on a job knowing there are bidders who do not care whether the work stands or not, and knows that in order to get the work he will have to bid so low that in case of the least bad luck he will lose money on the job, he feels as though he would just as soon not bid.

Any man who wants to let the contract for a building, first gets out his plans and specifications, and then submits them for bids, and upon awarding the contract to the lowest responsible bidder binds him under written contract to faithfully fulfill the specifications, but with the ordinary man who wants a cement walk built will go to the different parties he knows who are building cement walks and ask them for a bid, you ask him for his specifications, he will tell you he wants a good walk and that you know what it takes to make it, and you make him a bid on the basis of putting down a good walk, perhaps the next you hear of the job someone who has never laid a cement walk before in his life is putting in the walk, and you ask him why he got him to put down the walk he will tell you he is doing it for less than the regular sidewalk men asked for doing it, and ask him if the man knows enough to build a good walk and whether he is honest enough to build a good walk or not, he will say "I do not know"; he says he will do me as good a job as anybody. So you see the bulk of the walks built in the ordinary town is left entirely to the honesty of the man who builds them, and the man who builds good walks is left entirely to the mercy of the man who has no reputation or never expects to have.

You will find dishonest men in all classes, and why should a job of cement walk be left entirely to the man's honesty any more than the job of erecting a building? Why should not sidewalk builders be bound under specifications the same as any other builder? Honest men will not object to being bound under an honest contract, and dishonest men should be compelled to be bound under such a contract or not allowed to do the work.

Of course some one will say that a man could soon work up a reputation so people would know whether his work was all right or not, this is true where a man is located in a town large enough to furnish him all the work he can do, but when a man is in the exclusive cement business and located in the ordinary sized town there is not work enough to keep one ordinary sized gang busy, to say nothing of two or three gangs that may be

in the same town. When you consider that one gang of five or six men will lay about ten miles of 4 ft. walk in one season if kept busy in one town, how many towns are there in Iowa that would keep one gang busy all season? There are comparatively few. So consequently the man who is making the exclusive cement business his business must necessarily do work in strange towns every year, as the bulk of his work is away from his home, unless he is located in some of the larger Cities.

I think all who have had any amount of experience in the sidewalk business in the smaller towns will agree with me that there should be some steps taken to establish a Uniform Sidewalk Specification.

Some will say that it is impossible to have a uniform specification, as what will make a good walk in one place will not make a walk that will stand on another. I will admit that some cement walks will stand in some places while the same walk would not stand in other places, but a good walk will stand any place where any walk will stand, and a walk properly built should give practically the same results in all localities.

For the last ten years I have held very close to one specification for sidewalks, this one I adopted after making several experiments in the different ways of laying walks, and adopted the one that gave the best results.

I have laid walks in a great many towns covering nearly all the territory in northern Iowa, as well as some parts of Minnesota and North Dakota, and find that this same specification gives satisfactory results in all localities where I have worked.

I do not agree with most specifications on the question of fill, or foundation. I do not believe in excavating 18 in. or 2 ft. of good natural earth and replacing it with cinders, sand, brickbats or crushed stone as required by most specifications, as this is an unnecessary expense and adds nothing to quality of the walk. I claim it is what goes into the walk that makes the quality and not what goes under it.

In laying a walk I excavate to a depth of five inches below the sidewalk grade, on this place one inch of sand, then three and one-half inches of concrete, composed of one part of best Portland Cement to six parts of clean sharp sand and gravel of proper proportions, this to be thoroughly mixed dry then water enough added to allow moisture to raise to the surface after hard ramming, then upon this one-half inch of top coat or wearing surface composed of one part best Portland Cement and two parts clean sharp sand, this to be thoroughly mixed dry then add water sufficient to form a mortar; this should be put on as soon as the concrete is rammed in place before it has time to set or become dry. The top should be troweled to an even

surface and cut in squares of about three feet, although larger blocks are satisfactory in many localities.

In a great many places walks are laid with satisfactory results with nothing whatever between the walk and the natural earth; in these cases it is where the soil is naturally sandy, but I would advise the use of one inch of sand in all cases unless a man is thoroughly acquainted with the soil and knows that it is not necessary.

Every sidewalk gang should have at least one man who thoroughly understands the nature of cement, as sidewalk work is different than any other line of concrete work. I have known of many places where plenty of good material was used and the walk would go to pieces in a very short time because of the material not being properly handled .

A walk when finished after it has become too dry will become brittle and easily crumbled and if finished too wet the cement will settle away from the top and leave the surface sandy and it will gradually wear away under the constant travel, where in any other class of work it would stand perfectly satistactory. There is a proper time to do the finishing on a sidewalk to get the best results, and a man must understand the nature of cement to know when this time is, as there is hardly two days during the season that cement will work exactly alike. Some days it is necessary to follow up and finish as fast as the top coat is put on, while at times when the temperature is close to freezing point I have put down a walk in the afternoon and finished it the next day, with perfectly satisfactory results. If you get one batch drier than another it must be finished quicker, while if you get it too wet you must wait until it gets to the proper stage for finishing.

A walk laid as per above specifications will be satisfactory in any locality where I have worked, and I have laid walks on some of the worst ground to heave in Iowa. I have never had any trouble with walks built by these specifications.

A walk built in this way will be strong enough to take a slab six feet square and handle it without breaking, or it could be laid across an opening with a bearing under each end and carry the ordinary travel of a sidewalk without breaking, so it looks unreasonable that the ground heaving and lifting a walk up as the ground raises under it would break a good walk.

We all know that in cold weather concrete contracts while ground in freezing expands an dthat is what I claim is the caues
ground in freezing expands and that is what I claim is the cause
tom of the walk and expands while at the same time the walk is contracting from the effect of the cold, thus the one is pulling

directly against the other and consequently the walk must break to let the ground expand, and when you get sand enough between the walk and the ground to cause a separation and let each be free to act separately, the one to contract while the other expands, you have all the fill or foundation that is necessary between your walk and the natural ground.

As to the subject of cinders and brick bats, I do not approve of them being used under a walk at all unless it is in a place where fill is necessary to bring the surface to the sub-grade and then they should be well rammed and flooded so as to be made perfectly solid and a layer of sand used between that and the walk so as to keep the walk from coming in contact with them, to prevent them from drawing the moisture from the walk, as either will draw the moisture from a walk so quick that it loses a great deal of its strength.

In closing, I would suggest that this Convention take some steps in the direction of having a set of Standard Sidewalk Specifications drafted, and as fast as possible have them adopted and made an ordinance of every City and Town in Iowa. And one of the main clauses should be a clause demanding at least one first class workman on each gang, as a cement walk put in right will last an indefinite time, and should be finished in a workmanlike manner, as we are all aware there are a great many of them that are not.

Hoping these few points may lead to bringing out some better ones from some of the other sidewalk men present, I will now leave the question open for discussion.

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THE IOWA EN

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AMERICAN FUEL OIL

**By L. M. PAGE, Charles City, Iow*

Recent years have witnessed a marked incr
duction of petroleum in the United States. Th
largely to the remarkable output of California,
extent, to the increased production in Louisi
Indiana, and Kansas, and to the large productio
Texas.

These southern and western fields produc
tively low in valuable distillates, usually of aspl
yield such large quantities that the price is low
adding a considerable pecentage of the cost o
great distance from the wells.

The successful introduction of the use of c
as a fuel has solved the problem of cheap fuel i
oil fields producing the inferior grades of petrole
steam-ship lines, and manufacturers are being di
by its general introduction as an economical an

Because of the adaptability of these oils for
their increaing use in steam generation, this pap
the crude petroleums and fuel oils of the Unite
view to ascertain their values to power users
efforts were made to obtain representative sampl
and fuel oils from as many of the oil fields of th
as possible, particularly those nearest to Iowa.

Letters were addressed to leading oil pro

*Abstract from graduation thesis, June, 1905.

respective localities requesting samples for this purpose, viz. a comparative examination of the various American fuel oils. No reply could be elicited from many of the parties addressed, which fact accounts for an absence in this report of data concerning Ohio oils, and for the small number of samples from some of the other states. It is hoped, however, that although there is a variation in the properties of the oil from one district, and even at times from one well, the samples obtained and examined will correctly represent the different fuel and crude oils of the various fields.

In the examination of the oils the following properties were determined: flash point, burning point, viscosity, specific gravity, and* calorific value in British Thermal Units. The cost of the oil at the well or on board cars at shipping point was asked for and obtained for most of the samples. From this data the boiler-horse-power hours which might be obtained per barrel of oil was calculated, also the cost per hundred boiler-horse-power hours. The data also permitted calculation of the equivalent evaporation in pounds of water from and at 212° F per pound of oil, and per barrel of oil, the barrel being the standard U. S. barrel holding forty-two British Imperial gallons, the equivalent of 50 1-2 U. S. Standard gallons.

The calorific value of the oils is one of the most important characteristics to be determined, as on this and the specific gravity depend the fuel value to steam users.

The instrument used was one devised by S. W. Parr of the University of Illinois. Its marked features are accuracy, simplicity, ease and rapidity of manipulation, and the results obtained are absolute, not relative.

In calculating the equivalent evaporation, an efficiency of boiler and furnace had to be assumed and was taken as 59%, an average of thirty-five tests on an oil fired boiler conducted by the U. S. Naval "Liquid Fuel" Board in 1904. The equivalent evaporation in pounds of water from and at 212°F will equal the B. T. U. per pound of oil times .59, divided by 965.7, the B. T. U. required to evaporate one pound of water from and at 212° F.

The cost per barrel of oil was given by the parties furnishing the samples, except for the Santa Barbara Co., Calif. samples, the price of which was taken as the average price of the oil of that county F. O. B. in 1903, the latest figures obtainable for California crude petroleums.

It was hoped that some relation might be found to exist

*In this abstract attention is given chiefly to the determinations of calorific values.—Ed.

between some easily determined property specific gravity, or flash and fire points, and the B. T. U. per pound, but no relation could be discovered upon careful examination of the data obtained. It will be seen, however, that as a rule the petroleums having a high specific gravity have a high viscosity at ordinary temperatures as compared with other oils from the same state or field. In a much more general way this will also hold for the crude oils of the whole country.

It may also be noted that the calorific value of the crudes from one district vary but little, hardly more than will two samples from the same field, furnished by different parties. It is also the case that the reduced oils, those having some of the more volatile products removed, did not lose in calorific value, but gained in specific gravity. With these, too, the flash point was raised to a considerably higher temperature.

The odor of the Texas and Louisiana and some of the California oils was far from agreeable. The petroleums from farther east had odors much less offensive and some of them were even pleasant.

It would appear by examining the table of data that the oil which can be delivered at the lowest price to a power user is the most economical fuel oil for him to buy, as the evaporative powers of the different oils do not vary sufficiently to warrant much of a difference in freight bills.

Petroleum that is to be consumed inside of buildings or in steam vessels should not contain any of the lighter products, which are in many cases found even in the heavier crudes. It should have a fire test ranging from 220° to 270°F. Under these conditions it is safe to handle and there is no loss from evaporation.

DATA ON AMERICAN FUEL OILS

Name of Oil or Locality	Sample Furnished by	Flash	Fire	Viscosity Degrees Retardation At 68°F.	Viscosity Degrees Retardation At 180°F.	Specific Gravity at 60°F.	B. T. U. Per Lb	No. Tests	Cost Per Barrel 42 Gallons	Equiv. Evaporation from x at 212°F. Lbs Water Per Lb. of Oil
TEXAS										
a Corsicana, Narerro county	A. S. Morrill	196	274	65	18	.9080	19855	3	$ .50@.75	b 12.11
b San Antonio, Bexar county	Geo. Dullnig	228	284	96	23.5	.9105	19280	2	5.00	11.61
Beaumont (Spindle Top), Jefferson county	The Gulf Company	165	219	46	16	.9221	19664	2	d 55	11.99
" " " "	The Texas Company	163	212	58	14	.9177	19720	2	f .31@.38	12.04
Sour Lake, Jefferson county	Gulf Co., Port Arthur	108	214	....	....	.9074	18856	3	d 55	11.52
" " " "	Texas Co., Beaumont	136	211	62	19	.9230	18910	2	f .20@.35	11.55
Saratoga, Hardin county	Gulf Company	161	226	42.5	14	.9195	19263	2	d.55	11.77
" " "	Texas Company	180	242	72	17	.9305	19065	3	f .24@.35	12.00
Batson, Hardin county	Gulf Company	82	132	34	13.5	.8968	19793	2	d 55	12.00
" " "	Texas Company	83	132	48	15	.8902	19256	2	f .24@.35	11.77
Humble, Harris county	Gulf Company	166	214	38	14.5	.9261	19640	3	d.55	12.00
" " "	Texas Company	124	228	88	14.5	.9202	18040	2	f .10@.22	11.02
Reduced crude	Gulf Company	326	380	See curve	43	.9498	19297	3	d 55	11.78
Asphalt oil	Texas Company	370	....	"	77	.9767	20442	2	1.26	12.47
Steamer oil	" "	268	322	100	17.5	.9285	19291	2	.84	11.78
LOUISIANA										
Jennings, Calcasieu county	Gulf Company	194	233	32	12.5	.9050	20193	2	d.55	12.35
" " "	Texas Company	192	219	32	12.5	.9063	19908	3	.17@.27	12.16
CALIFORNIA										
Hartnell No. 1, Santa Barbara Co.	Union Oil Co. of Cal.	70	87	126	23	.9022	18530	3	c 57	11.34
Giant Oil, Kern county	Associated Oil Co. of Cal	240	305	See curve	40	.9669	18401	4	.225	11.26
Shamrock, Kern county	" "	119	147	85	19	.9349	18900	3	.225	11.54
Whittier, Los Angeles county	Central Oil Co. of Los Angeles	148	208	130	26	.9465	17822	4	.55@.65	10.88
Sunset, Kern county	California Consol. Oil Fields Co.	222	296	See curve	57	.9684	18732	3	.225	11.45

a A fuel crude, about 10 per cent. water.
b Sold as a lubricant
c Price f. o. b shipping point, 1903.
d Price f. o b. refinery, Port Arthur, Texas.
f Prices at wells.

DATA ON AMERICAN FUEL OILS

Name of Oil or Locality	Sample Furnished by	Flash	Fire	Viscosity Degrees Retardation At 65°F.	Viscosity Degrees Retardation At 150°F.	Specific Gravity at 60°F	B T.U. Per Lb	No. Tests	Cost Per Barrel 42 Gallons	Equiv. Evaporation from and at 212°F. Lbs of Water Per Lb. of Oil
COLORADO										
Boulder, Boulder county	United Oil Co.	Below 66	66	11.0	11.0	.8211	19650	4	$ 1.10	12.00
Florence, Fremont county	" "	164	205	31.0	14.0	.8807	18103	3	.80	11.67
OKLAHOMA										
Granite, Greer county, lubricating	K. C. Cox	Above 245	....	See curve	61.0	.9357	ab't 18500	1	10.00	11.30
KANSAS										
Erie, Neosho county	Midland Oil & Gas Co., K. City, Mo.	157	208	68.5	19.	.9006	18714	3	.72	11.44
Altoona, Wilson county	....	130	181	32.	17.5	.8697	19210	4	....	11.74
Longton, Elk county	Allen County Investment Co.	Below 64	121	28.	16.	.8717	19004	2	a.47@.57	11.62
" " "	Superior Oil & Gas Co.	62	84	23.	13.	.8707	19380	2	a.47@.57	11.85
INDIANA										
Whiting, fuel oil	Standard Oil Co.	212	318	18.	12.5	.8654	19400	2	b1.47	11.87
Delaware county, crude	J. R. Penn, Jr.	Below 22	40	14.	12.5	.8283	19271	2	a .86	11.77
WEST VIRGINIA										
c Big Injun Sand, Monnington	So. Pennsylvania Oil Co.	Below 32	50	11.	10.	.8002	19400	2	1.39	11.87
c Gordon Sand	" "	45	81	22.	11.	.8145	19350	2	1.39	11.83
c Fifth Sand	" "	39	83	24.	12.5	.8162	19230	2	1.39	11.75
PENNSYLVANIA										
c Bradford crude	Emery Mfg. Co.	Below 66	96	12.5	11.	.8076	19600	2	1.39	11.97
Fuel or gas oil	" "	156	173	13.5	11.	.8370	19090	3	....	12.02
c Pennsylvania crude	" "	40	79	12.5	11.	.8192	19632	1	1.39	11.98
Butler county crude	F. H. Oliphant	128	180	21.	11.	.8387	20560	2	....	12.55
Distillate, fuel oil, New York	Standard Oil Co.	232	280	20.	11.	.888	19700	3	b1.58	12.03

a Price at the wells. b Price delivered. c Not used as a crude for fuel purposes.

THE DERMINATION OF FAULTS IN A DIRECT CURRENT ARMATURE

By ADOLPH SHANE, Iowa State College

Armature troubles are not infrequently met in an electric lighting or power plant, but the smaller the plant the fewer facilities there are usually for locating the fault or faults which might otherwise mean the saving of both time and expense. It is in the interest of the small plant that this article is especially written, though the methods are exact enough to be applicable in any place where the troubles enumerated below might exist. With this end in view but few instruments or apparatus have been considered necessary and these likely to be found or easily made up with the supplies on hand.

The common faults that might exist in an armature may be classified as follows:

(a) Short circuited coil in armature.

(b) Commutator connector not making contact with commutator bar, though the armature winding proper might not be broken.

(c) Broken circuit in armature winding.

(d) Ground in armature.

Any one or more of these faults existing might be indicated by more or less violent flashing at armature, excessive heating of armature, and excessive load on belt if a generator, or excessive power consumption if a motor, as explained with some detail in Crocker and Wheeler's "Practical Management oi Dynamos and Motors." The following tests should then be applied after stopping the machine:

(a) Short Circuited Coil in Armature. This is likely to occur by a piece of solder or other metal getting between the commutator bars, and sometimes the insulation between the ends of these bars is bridged over by a piece of metal, in which case the remedy could probably be applied on the spot. All but the two opposite sets of brushes should be lifted off the commutator if a multipolar machine, and by way of these two remaining brushes, or the existing brushes if a bipolar, a fairly strong continuous current of from 10 to 100 amperes is sent through the armature, depending on the size of the machine or sensitiveness of the indicating instrument, which is a direct current ammeter of the Weston type with the shunt removed. The connections are indicated in Figure 1.

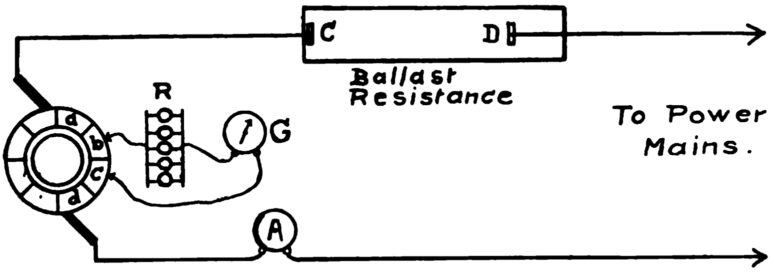

Figure 1.

Here G is the indicating instrument without the shunt, R is some variable resistance in series with it (such as a lamp bank) and A is an ammeter of any form. The ballast resistance can well consist of a wooden trough containing salt water, C and D being carbon or metal electrodes. If access to a storage battery can be obtained this resistance can be dispensed with and the strength of current varied by cutting a cell in or out. Drops between every adjacent pair of commutator bars are taken by means of G, as between a and b, b and c, c and d, etc. If the drops are all fairly uniform in value no short circuit exists. But should one pair of bars have no drop the cause is a short circuit at the commutator between these pairs. If a deflection exists but considerably less than the normal, the cause is either a double ground in the particular coil, or a short circuit of part of the coil. In either case the effect is that of a short circuit with consequent heating when the armature is running.

The current in the armature should be kept constant during this test and those following. The sensitiveness of G may be adjusted by inserting or taking out lamps at R, and if necessary for more positive indications, the current may be increased. It might even be necessary to dispense with R altogether, but as a precautionary measure it should first be inserted.

(b) Commutator connector not making contact with commutator Bar. If two adjacent pairs such as ab and bc both have zero drop, the cause might be two short circuits, but more probably a lack of contact between the coil connector and b. This can be proven by touching the terminals of a battery and bell between b and its connector. If no ring is evident the latter is the cause.

(c) Broken Circuit in Armature. If an entire series of pairs of bars are tested and found to give no deflection, and suddenly one particular pair gives a high reading, a broken circuit in the armature is the cause, the fault existing between the pairs giving the high reading.

(d) Ground in Armature. A "magneto" or battery and bell connected between the shaft and the copper of the armature will detect this, the latter indicating a very low resistance or short cicuit to ground. If only a single ground the machine will run satisfactorily provided no other circuit connected to the machine is also grounded. Yet even a single ground should not be permitted to exist. If only a single ground as indicated by the running test, it may be localized by connecting up a circuit as shown by Figure 2, a fairly strong current being permitted to flow through the ground. Only one brush is left on the commutator. If one terminal of G is connected to the shaft and the other passed from one commutator bar to the next with

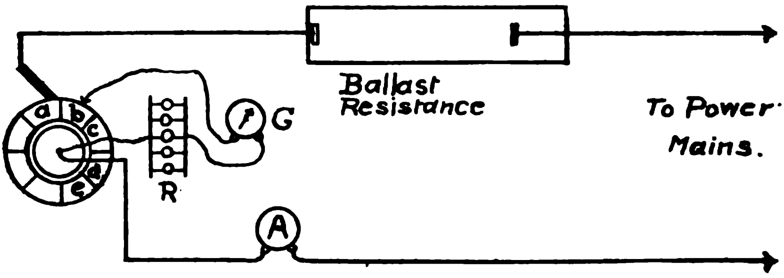

Figure 2.

corresponding deflections noted, a series of diminishing or increasing deflections will result depending on whether progress is being made towards or away from the ground. If the terminal of G be passed around the commutator in the direction of diminishing deflections a point will be reached where a minimum deflection exists, after whicn tiey increase again. The ground lies at the point where this change takes place. To exactly locate it between a pair of commutator bars, the armature must be rotated until the readings of the one set of deflections decrease with the same increment that the readings increase with on the other. This is done by slightly turning the armature one way or the other until the desired result is obtained. In Figure 2, the terminal of G is passed from a to b to c, etc., and beyond the bar c the deflections decidedly increase while in going toward b they diminish. The armature should be rotated until the decrease in deflections of G towards b just equals the increase away from C. If the ground lies exactly in the coil between b and c, the deflections at b and c are each less than the amount of increase or decrease on either side of these bars. In fact the two deflections added together should

just about equal the amount of increase or decrease as the contact passes around from one bar to the next.

If the ground is a short circuit the relative distance away from one of the bars may even be estimated as follows: If the deflection, with the terminal of the indicator at b is B and when at c it is C then B divided by B plus C represents the ratio of the portion of the coil between b and the ground, to the whole length of the coil between b and c.

To measure the extent of a slight ground on a machine a high resistance voltmeter may be placed in series with the ground as shown in diagram by Figure 3, and the terminals connected to a source of pressure.

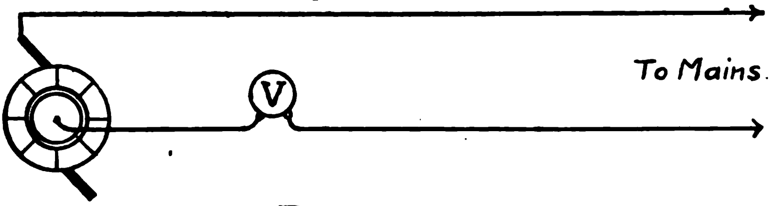

Figure 3.

The resistance to ground is given by the formula

$$R=\frac{r(E-e)}{e}$$

where R is the required resistance

r is the resistance of the voltmeter.

E is the pressure.

e is the deflection when the voltmeter is in series with ground.

*The Relations of Railroads, as Common Carriers, to the State and Federal Governments

By HON. J. C. DAVIS, Des Moines

In presenting this paper I want to disclaim any intention on my part of advocating any personal opinion or theory in connection with this important question, my desire being not to suggest new methods or theories, or to criticise the existing situation, but to give with some degree of accuracy the present relations, from a legal standpoint, of the State and Federal Governments to the great corporations engaged, as common carriers, in transporting the freight and passenger commerce of the land.

This question, to be intelligently considered, must have some relation to the wonderful growth and development of the transportation system in the United States. The history of the

*Lecture delivered at Iowa State College, September 14, 1905.

physical development of railroads, the wonderful perfection of service, and the magic expansion in lines of road is as interesting to the student of this subject, as is the growth and gradual settlement of the great questions which arose between the public on the one side—as represented in some jurisdictions by the state government, and in other jurisdictions by the national government,—and the corporations which have constructed, absorbed, controlled, and now maintain these lines of road. A brief outline of the history of the construction of railroads in this country may not be inappropriate.

When we consider that there are men still living who can remember when there were no railroads in the United States,—when we recall that within the memory of these men there were grave discussions in legislative assemblies, and in the public press, as to the relative merits in the way of speed and reliability between horses, canal boats, and steam railways, the present perfection of railroad transportation, is a splendid tribute to the ingenuity, courage, and enterprise of American genius. It is no phrase of poetry or oratory to say that railroads have annihilated distance, overcome mountains, and made traveling through barren and desert wastes safe, convenient, and in a measure luxurious and enjoyable. It is also a statement of fact rather than a pleasant vagary of fiction, when we say that the railroads of America have been the most potent element in the general settlement, and prosperity of the country at large.

The rapid growth of railroad construction; the creation of new and controlling methods of transportation; the employment of an army of men in a single line of business; the existence of real and fancied grievances, in which it was claimed the service of these corporations was not extended with fairness and impartiality, led in that period after railroads had passed the experimental stage to some bitter controversies and some antagonism between the general public and the railroad interests. Happily at this time these mooted and strenuous questions have been largely settled, and I believe that today a candid and impartial investigation will establish the proposition that the railway companies of this country are giving to the public fair, efficient, and adequate service, fully recognizing that such companies are in the nature of quasi public corporations, performing, to a large degree, a public service, and that the public is obtaining, in return for the compensation which it pays to these carriers, value received.

The commercial interests of the land—and by commercial interests is meant all which produce property for sale or exchange, including the mines, the farms, the factories, as well as

strictly commercial enterprises,—must be in accord with the transportation interests. These two great factors, the shipper on the one side and the carrier on the other, are absolutely dependent upon each other. When the shipper is prosperous, and has an abundance of freight for carriage, the railroads share in that prosperity, because of the bulk of freight offered for transportation. If business languishes, and the shipper has but little to offer for carriage, there is a corresponding diminution in the prosperity of the carrying companies. This community of interest has come to be largely recognized by the controlling managers of the great transportation companies, as well as the communities which create or raise a surplus of products to be shipped to distant markets, or which receive in the course of trade the products of other lands, and when differences of opinion arise, whether such differences exist between the individual shipper or the community which is served by some particular line of road, such differences in the great majority of cases, are satisfactorily adjusted by an amicable meeting and a frank interchange of views by the interested parties, and, as a better understanding as to relative rights and obligations is had, there is less friction, and fewer resorts to courts and commissions.

In considering the growth and development of railroad interests, the time of such growth is ordinarily divided into three periods.

From 1830 to 1850, during which time the construction of railroads was to some extent in an experimental stage, practical railroad building in the United States commencing, in a general way, about 1830. During this first period while railways were, as a general rule, constructed by private companies, there were some attempts on the part of several state governments to construct and operate roads.

These attempts were not of long duration, were not successful, and after a little while were abandoned.

In the second period, from 1850 to 1870, during which time the science of railroading was rapidly developed, the construction, maintenance, and operation of railroads was largely turned over to private enterprise, the various governments, state and national, not attempting to exercise any general or specific control, the belief being that competition between the independent lines of road would obtain for the public all that government control or ownership can ever obtain, namely, reasonable rates and safe and convenient service.

The third period, from 1870 down to the present time, represents the beginning and growth of government control. During this period the attitude of the state and federal govern-

ments towards railroad interests was altered, in that there was evolved the theory of government control in a great multitude of instances, the state governments exercising control over those local matters which come under the general definition of police power, and also exercising control over the transportation of freight and passengers when the carriage is confined wholly to points within the specific state or territory; the federal government at a little later period assuming charge and control of those larger interests which are denominated as interstate, and also the commerce between the United Itates and foreign countries.

This generation can scarcely realize the difficulties which the pioneers in railroad building were obliged to overcome. The first scheme, as I understand it, in railroad building contemplated a level way, which should be open to the public as an ordinary road, and over which every vehicle, whether drawn by steam or animal power, should have equal privileges. A little further development created rails, which were made of wood, but the same general principles as to equal rights upon the road were maintained.

A reference to some of the early discussions in regard to the practicability of railroads, in the light of the present development of this great business, may not be uninteresting. It is reported that Robert Fulton, of steamboat fame, in 1811 made this prophecy:

"The day will come, gentlemen, I may not live to see it, though some of you who are younger will probably, when carriages will be drawn over these mountains by steam engines, at a rate more rapid than that of a stage on the smoothest turnpike."

In 1812 Mr. Oliver Evans, who was one of the earliest experimenters in building steam carriages, said:

"Some wise men undertook to ridicule my experiment of propelling this great weight (which consisted of a weight equal to about two hundred barrels of flour) on land, because the motion was too slow to be useful. I silenced them by answering that I would make a carriage to be propelled by steam, for a bet of $3000.00 to run upon a level road against the swiftest horse they would produce. I was then as confident as I am now that such velocity could be given to carriages."

In the same communication Mr. Evans made this prophecy:

"When we reflect upon the obstinate opposition that has been made by a great majority to every step towards improvement: from bad roads to turnpikes, from turnpikes to canals, from canals to railways for horse carriages, it is too much to

expect the monstrous leap from bad roads to railways for steam carriages at once. One step in a generation is all we can hope for. If the present shall adopt canals, the next may try railways with horses, and the third generation use the steam carriages. I do verily believe that the time will come when carriages propelled by steam will be in general use, as well for the transportation of passengers as goods, traveling at the rate of fifteen miles an hour, or three hundred miles per day."

And at a later time, in 1813, this pioneer in the matter of steam carriages, said:

"The time will come when people will travel in stages moved by steam engines from one city to another, almost as fast as birds fly, fifteen or twenty miles an hour."

As late as 1836 the following account is recorded of the trial of a steam engine with which it was proposed to carry fifty passengers up an inclined plane at Schuylkill:

"In 1836 my friend William Norris invited me to meet a number of gentlemen to witness a promised performance of one of his locomotives, namely to take a passenger car (eight-wheeled) with fifty persons in it, up the Schuylkill inclined plane at the rate of ten miles an hour. The first morning this experiment was to be tried it was found that some malicious or humorous individual had greased the track, which prevented the test for that time but shortly after, when the grease had been removed, his locomotive actually performed as he had promised.'

Even after steam carriages upon railroads were in service, the roads were operated upon the theory that any one could use the rails with his own carriage for transportation. As was said in a History of Early Railroading:

"After the state of Pennsylvania had solved the first difficulty by excluding horses, and providing locomotives to furnish motive power, all the vehicles or cars used in moving freight or passengers continued to be owned by individuals, firms, or private corporations until the commonwealth disposed of her public works, after her railways had been in operation under state management for nearly a quarter of a century."

An account of a discussion between two members of the Pennsylvania legislature, in the early days, is recorded as follows:

"Two gentlemen were sitting opposite me who were members of the legislature from Chester County, one being a senator. The car stopped, and a man spoke to my traveling companion, saying that he hoped they would oppose the bill to authorize the canal commissioners to put locomotives on the

road and control the motive power. The senator said that it should never be done with his consent. Thereupon, as the car drove on, I proceeded to argue the matter, but with poor success; the reply being that the people were taxed to make the railroad, and that the farmers along the line should have the right to drive their own horses and cars on the railroad as they did their wagons on the Lancaster turnpike, to go to market in Philadelphia; and that, if they were not permitted to do it, the railroad would be a nuisance to the people of Lancaster and Chester Counties."

When we consider the perfection of railroad operation as it is found today, the wonderful progress in mechanics which has produced the modern locomotive, the system of block signals, the mechanical appliances, of which there are a multitude in all yards and terminal points, the system of electric communication by telegraph, and other signals, an incident or two in early railroading emphasizes the development of this industry.

As late as 1837, there being no telegraph system, the method of determining how trains should be prevented from meeting between stations is described as follows:

"The poles were of cedar, quite like those now in use, and had cleats fastened on them, forming a sort of Jacob's ladder. The telegraphing was done thus: The operator would go to the top of the pole forming his station, and with his spy-glass sight the next station in the direction of the approaching train. If the train was coming, and the signal showed a flag, it meant all is well. If a big ball was shown, and no train in sight, it signified an accident. These signals were methodically exchanged until an understanding was had from one end of the road to the other."

The manner of signalling from conductor to engineer is thus described:

"The manner of stopping trains then, in contrast to the modern method of simply pulling a bell rope, was something altogether novel. The conductor ascended a ladder to the roof of a car, and then ran forward to within hailing distance of the engineer, to whom he imparted the signal verbally. There was a great deal of briskness required of the conductor in the old days, and running along the tops of cars o na dark night was not as comfor... ..e a task as one might wish for. There were no bell ropes, and the steam whistle had not been thought of."

An old conductor, in his reminiscences of early railroading, gives the methods of signaling as follows:

"The first practice of railroad signals that I remember was a system of conveying a sign to the engineer by a movement of

the fingers. For instance, if I wanted to stop at the Falls, I held up one finger; Wissahickon, two fingers; another station three fingers, and so on."

The following method of stopping a train in the very early days is interesting:

"At one time the chief reliance was upon the activity of the engineman in checking the speed of the locomotive, but this was often insufficient. It is stated that on the New Castle and Frenchtown Railroad the braking of the train when near the station—Frenchtown or New Castle—was done at the signal of the engineman by raising his safety valve. Then the old colored slaves would rush to the train, seize hold and pull back while the agent would stick a piece of wood through the wheel spokes."

A primitive locomotive head light is thus described:

"In making prospective arrangements for this unusual undertaking (to run a train at night) one of the first things that occurred to him was that the locomotive would have to run by night as well as by day, and, in the absence of a head light, he built on an open platform car, stationed in front of the locomotive, a fire of pine knots, surrounded with sand, which furnished the requisite illumination of the route traversed."

One of the early contentions which railroad managers were obliged to overcome was the contest between horses and locomotives in the right to carry the mails, and for a very considerable period after railroading had been inaugurated horses were considered the safest and swiftest method by which the mails could be transferred. A contest between Peter Cooper's "Tom Thumb," an engine of his own construction, and a powerful gray horse is described as follows:

"It was not until the first railways had been in operation for several years that the locomotive fully established its superiority over the horse in point of speed and reliability. Shortly after the opening of the first section of the Baltimore and Ohio railway to Ellicott's Mills, or in the summer of 1830 Peter Cooper, running the 'Tom Thumb,' a locomotive of his own construction, was distanced by a powerful gray horse drawing a car which by this victory became famous, and later played a conspicuous role in the public prints and early books on travel."

These quotations illustrate what a great development has occurred in a comparatively short time. As late as 1850 there was not a mile of railroad in Wisconsin, Tennessee, or Florida, and little, if any, construction west of the Mississippi River. Even in 1870 it is said that one-half of the area of the country was still without railways. Ordinarily it is said that the first

American railway, which, however, was not built for steam cars, was made to haul Quincy granite for the Bunker Hill Monument. This road was three miles long. The first extended railway, built for steam cars, is said to have been the Charleston and New Hamburg line, in South Carolina. This line was 137 miles long, and for quite a period was the longest railroad in the world.

Comparing the early condition of railroad construction with the present extent of mileage and capital invested, the comparison becomes almost bewildering. According to a late report of the Interstate Commerce Commission, the aggregate miles of main line mileage in the United States was some 205,313 miles, more than enough to make an eight-track railway around the world. To operate this great mileage there were 43,871 locomotives, 1,753,389 freight cars, and more than 37,000 passenger cars. At the close of the year ending June 30th, 1902, the total number of employes upon the railways in the United States was 1,189,315, and these employes supported some six millions of people. The aggregate amount of salaries and wages paid was in excess of $676,000,000. The combined capitalization of the railroads at this period was in excess of $12,134,000,000, representing a valuation of about $62,000 per mile. The gross earnings of the railroads of the United States, for the year ending June 30th, 1902, were more than $1,726,000,000, the operating expenses were over $1,100,000,000, leaving the net income somewhat in excess of $650,000,000, or about five per cent. on the capitalization of the railroads. The number of passengers carried was 649,878,500, an increase of more than 42,000,000 over the preceding year. The number of tons of freight carried one mile was in excess of one hundred and fifty-seven billion, and the amount of taxes paid by the railroad companies was about $55,000,000, or nearly ten per cent of the net earnings of the companies.

The railroad interest in Iowa—with the exception of agriculture—is the most important that we have. We have 9,719 miles of single main track; 675 miles of second main track; 2271 miles of side track, making a total mileage, of main and side track, of 12,665 miles. This railroad property is valued by the Executive Council at $226,164,052, and the aggregate taxes paid by railroads in the state of Iowa last year were $1,874,419. It is said that there is not a point in Iowa where one can stand fourteen miles distant from a railway track.

These general statistics state more eloquently and forcibly than picturesque language the influence which the operation,

maintenance, and extension of railroads has on the commercial and finacial life of today.

The rapid growth of railroad construction has created a necessity for the existence of new laws, or what may be more accurately termed the application of old principles to new surroundings. There was no railroad law seventy years ago, for the reason there was practically no subject to which such laws should be applied, but there is an elasticity underlying the principles of the common law, upon which our whole theory of jurisprudence is founded, by which the old and everlasting principles of that law are made applicable to new and original surroundings, the development of the law in many new branches, such as railroad, telegraph, telephone, and the many uses ot electricity, all bear evidence.

In considering the relations of our state and federal governments to common carriers, the dual form of our government must be borne in mind; the fact that we have two independent governments exercising power and authority within the same territory, the several state governments acting upon matters local and within the boundaries of each particular state, the federal government supreme in those matters which are national, and those numerous and important transactions as to the relations between citizens of different states. This double exercise of authority at times gives rise to some complications.

You are all familiar with the theory of written constitutions. In England Parliament has no limitation upon its authority. The power of Parliament in the realm of legislation is ordinarily supreme. The people of America, smarting under the influence of this unlimited governmental power, sought to limit the authority of the various branches of our government by written constitutions. Hence we find the authority of the several states and the authority of the United States Government limited and defined by written constitutions.

In the adoption of the present Federal Constitution, the several states surrendered certain powers to the federal government, and in my judgment the most important power, and one which is most responsible for our present splendid prosperity, is that power found in Section 8 of Article I, known as the "Commercial Clause of the Constitution," which provides:

"The congress shall have power to regulate commerce with foreign nations, and among the several states, and with the Indian tribes."

It is this clause of the Constitution which marks the line of jurisdiction between the several states, upon one side and the federal government upon the other. The great Chief Justice

of the United States, John Marshall, in his liberal and elastic construction of that clause of the constitution, made absolute free trade between the several states, and prevented the selfish jealousies of one state or one community from interfering with interstate commerce.

Under the constitution the federal government at Washington has jurisdiction over all commerce, whether by rail, or water, or whatever the means of transportation, as between the several states, foreign countries, and the Indian tribes. On the other hand the states reserve to themselves the complete control of all commerce that originates and terminates wholly within state boundaries, and by applying the two rules, which it must be admitted at times run very close together, we find the jurisdiction of the two governments acting upon the question of transportation.

As heretofore suggested, the period of 1850 to 1870 represents the time when railroad construction and operation became an established success. The development of new country, the opening of agricultural lands for settlement, created a great demand for railroads and the sentiment of the general public was all in favor of extension. The public, by various kinds of donations, aided the construction of railroads. They were granted special powers by the legislature, among them the power of eminent domain, which authorizes a railroad to enter and appropriate so much of the private property of any individual as may be necessary for the proper use of the road, this appropriation being on the payment of just compensation. Most of the states passed laws authorizing special taxes to be voted by counties, townships, and municipalities in aid of railroad construction. There were magnificent donations of public lands made to railroads, especially to those that contemplated construction to the Pacific Ocean.

During this period the government made no pronounced effort to control the management and operation of railroads, but it was believed that the ordinary rules of competition would give the public convenient service for reasonable compensation.

As the railroads continued to grow in strength and power, abuses, some of which were actual, some magnified, grew up. There being no law regulating the charge for carriage, discrimination arose; favored shippers received rates that those less favored did not enjoy; one community was discriminated against in favor of another; cities which happened to be the terminus or touched by two railroads would receive competitive rates much lower than those accorded to cities and towns not so for-

tunately situated; long hauls on the same lines of road were made cheaper to points of competition than shorter hauls of the same class of commodity to cities where no competition existed, and out of this situation there arose a great contest which should finally determine the character of railroad corporations; whether or not they were mere private enterprises, or whether or not these corporations were subject to governmental control.

The line of dispute was clearly drawn. The railroads, by their owners and managers, contended that they were private corporations; that their franchises, granted by the several states, contained no suggestion as to government control; that each railway represented a large investment, made as mere private institutions, and constitutional provisions would be violated if they were not permitted to control their property and use it as any private individual. The public, on the other side, contended that a railroad was nothing more or less than an improved highway; that highways and turnpikes had from time immemorial been constructed and controlled by the government; that, if the government permitted a private individual or corporation to perform this public service, it did not, therefore, lose control over the private individual or corporation while such individual or corporation was performing a public service. It was further contended that the great privileges, especially the right of eminent domain, which were granted to railroads, and the large contributions which were made by the public to their construction, gave the public an interest in and control over this property.

The state of Iowa was especially the theater for this discussion. This state is peculiarly dependent upon transportation facilities. The value of our great surplus products, cattle, horses, hogs, corn, hay and dairy products, depends upon same being transported expeditiously and cheaply to distant markets. Those essentials and necessaries of life which we do not raise depend for their price to our people upon their being brought from distant lands and distant markets to our doors, and Iowa was one of the pioneer states in this discussion.

The first law enacted by the state of Iowa, seeking to control railroads, was approved March 23rd, 1874, and sought by a schedule prepared by the legislature to fix maximum rates for freight and passenger carriage. This law attempted great detail in the matter of classification, and contained the specific rates on more than 1200 classes of articles. As may be supposed, the freight tariff prepared by a legislature without any special training in this matter was not a success, for the science of freight rates is the most complicated, delicate, and serious

problem which railroad men have to deal with, and it requires an expert rather than an amateur to arrive at a correct conclusion.

In 1878 this law was repealed, and there was enacted in its stead provisions establishing a Railroad Commission. This Commission's powers were advisory only, the Commission having no authority to enforce its findings or orders. It was expected that the investigations and conclusions of the Commission, made public by reports to the Governor and the legislature, and the railways themselves, would be sufficient to correct such abuses as were brought to their attention. This law was in force for about ten years, when it was repealed.

In 1888 the present Railroad Commissioner's law was enacted, which grants to the Railroad Commissioners quite general powers, among which is the right to fix maximum charges for the carriage of freight and passengers, and the findings of the present Commission may be enforced by proper proceedings in the District Court.

The right of the legislature to enact laws of this character was contested in the courts, and it is interesting to consider the reasons upon which the courts finally sustained the right of governmental control.

In October, 1876, there were submitted to the Supreme Court of the United States several cases involving the validity of a number of state laws, having for their object government control of companies engaged in performing public services. There was a ware house and commission law from Illinois and Railroad Commissioner laws from Iowa and Wisconsin up for construction. The Supreme Court of the United States, in case of Munn vs. Illinois, reported in 94 U. S., 124, delivered an elaborate opinion which forever settled in this country the right of state governments, and, in an appropriate jurisdiction, the right of the federal government, to control quasi public corporations. The Court, in this opinion, said:

"When one becomes a member of society, he necessarily parts with some rights or privileges which, as an individual not affected by his relations to others, he might retain. 'A body politic,' as aptly defined in the preamble of the Constitution of Massachusetts, 'is a special compact by which the whole people covenants with each citizen, and each citizen with the whole people, that all shall be governed by certain laws for the common good.'"

In further speaking of the laws of government, the Court said:

"Under these powers the government regulates the con-

duct of its citizens, one towards another, and the manner in which each shall use his own property, when such regulation becomes necessary for the public good. In their exercise it has been customary in England from time immemorial, and in this country from its first colonization, to regulate ferries, common carriers, hackmen, bakers, millers, wharfingers, inkeepers, etc., and in so doing to fix a maximum of charge to be made for services rendered, accommodations furnished, and articles sold."

And the right of government control was laid down in the following language:

"Property does become clothed with a public interest when used in a manner to make it of public consequence, and affect the community at large. When, therefore, one devotes his property to a use in which the public has an interest, he, in effect, grants to the public an interest in that use, and must submit to be controlled by the public for the common good, to the extent of the interest he has thus created. He may withdraw his grant by discontinuing the use; but, so long as he maintains the use, he must submit to the control."

As an instance of government taking control of persons engaged in public service, a statute passed in England in the time of the reign of William and Mary, in the latter part, I believe, of the Seventeenth Century, had the following preamble:

"And whereas divers wagoners and other carriers, by combination amongst themselves, have raised the prices of carriage of goods in many places to excessive rates, to great injury of the trade: Be it therefore, enacted," etc.

This ancient statute illustrates that combinations of carriers to raise the prices is neither a new nor a modern condition.

In a latter case (143 U. S., 549) a more specific rule, as applied to railroads, was stated as follows:

"The creation of all highways is a public duty. Railroads are highways. The state may build them. If an individual or corporation does that work, he is pro tanto doing the work ot the State. He devotes his property to a public use. The State doing the work fixes the price for the use. It does not lose the right to fix the price, because an individual or corporation voluntarily undertakes to do the work."

This placed the right of government control upon the fact that railroads are nothing more than improved highways; that the state has always exercised control over public roads, and by virtue of the same principle would exercise authority over railroads, treating them as new ways, subject to old rules.

Without dilating further upon these or subsequent rulings, the Supreme Court of the United States, in these and later

opinions, sustains the right of the state and federal government to, in certain particulars, regulate the conduct and the business of common carriers, an essential to this being that the regulation must be reasonable, and, if a rate is fixed which does not pay to the carrier just compensation for the services performed, which means such reasonable compensation as will enable the carrier to maintain and operate his line, provide for depreciations, and pay a reasonable profit upon the capital engaged, the courts will set aside regulations that do not so provide, as unreasonable.

The line of demarcation between the federal government and the state government has been defined by the Supreme Court of the United States as follows:

"Commerce with foreign countries and among the states strictly considered, consists in intercourse and traffic including in these terms navigation and the transportation and transit of persons and property, as well as the purchase, sale, and exchange of commodities. For the regulation of commerce as thus defined there can be only one system of rules, applicable alike to the whole country; and the authority which can act for the whole country can alone adopt such a system. Action upon it by separate states is not, therefore, permissible."

There have been many attempts by state legislatures to exercise control over commerce not wholly within the borders of the state. This has been done by levying taxes, requiring licenses, providing regulations as to speed, operating trains on Sunday, and in other ways, but in every instance the Federal Courts have restrained such action. The wisdom of preventing individual state action on this subject is apparent, for otherwise a through shipment from New York to California might be burdened and detained by as many different regulations, taxes, and licenses as there are separate states through which it would pass, and the only way to maintain free commercial intercourse, as between the several states, is to jealously prevent any sort of state interference with all matters of commerce which are of national concern.

Under this right of government control the state of Iowa has legislated upon a variety of subjects, providing, among other things, for fences on right of way; cattle guards and signs at highway crossings; limit of speed at station grounds; liability for stock killed and penalty of double damages for failure to pay, creating liability, under certain circumstances, for damages by fire set out by locomotives; providing for interlocking switches where one railroad makes a surface crossing with another railroad; requiring signals by bell and whistle at railroad

crossings; creating the peculiar liability making railroads liable for injuries received by their employes, who are connected with the operation of the railroad, through the negligence of co-employes engaged in the same employment,—a liability which applies to no other corporation or individual employing labor; making judgments for injuries to persons or property liens upon railroad property prior to existing mortgages, and has also created a Railroad Commission, composed of three members, elected for terms of three years, with a salary of $2200.00 a year.

This Commission has general supervision of all the steam railways operated wholly within the state of Iowa. It can require investigation of all complaints; compel annual and other reports, and require its orders to be obeyed, if made within proper authority, by proceedings in the District Court. It further has power to fix maximum freight and passenger charges, so far as transportation is limited to points wholly within the state of Iowa.

There are also statutes requiring charges to be reasonable, and prohibiting unjust discrimination, pooling contracts, etc.

The federal government did not enact laws looking to the regulation of railways until the 4th of February, 1887. At that time a law was passed entitled "An Act to Regulate Commerce." This law applied to all common carriers engaged in the transportation of freight or passengers wholly by rail, or partly by rail and partly by water, when such carriage contemplates transportation from one state to another, from a state to a foreign country, or through such foreign country, or to points for transhipment to a foreign country, or shipment or carriage from foreign countries to the United States, and expressly excepts from its terms transportation of passengers or freight wholly within any state or territory.

This law expressly provides that all charges for services of common carriers shall be reasonable and just; prohibits any special rebate, rate, drawback, or other device, charge, or demand whereby service shall be rendered at a greater or less compensation than shall be charged to all persons "for a like and contemporanous service in transportation of a like kind of traffic under substantially similar circumstances and conditions;" makes it unlawful to give any unreasonable or undue advantage to any particular person, company, firm, corporation, or locality, or to any particular description of traffic, and requires equal facilities for interchange of traffic with connecting lines; prohibits all pooling agreements; provides for public posting of rates for freight and passengers, and prohibits any change in

such rates, either raising or reducing same, without ten days' notice before a rate can be raised and three days' notice before a reduction can be made.

A Commission of five members was created by this law, at salaries of $7500.00 each, known as the Interstate Commerce Commission. This Commission is clothed with authority to investigate violations of the law, grant hearings, and, while it has not as large powers as the State Commission, the purpose of the Commission is to investigate any charges which would indicate that interstate railroads are not giving fair and just treatment to the public.

Congress also, in 1893, passed laws requiring railroads engaged in interstate commerce to equip their engines with driving wheel brakes, so that the engineer could control the speed of the train, and requiring automatic couplers and safe grab irons or handholds at the end of each car.

In addition, by legislation upon this subject, the federal government has provided for inspection of meats, and, in some instances, food products, and prohibits railroads from transporting meats intended for export, unless the same have been properly inspected.

So you will discover, by this summary of the laws passed by the State of Iowa and the Congress of the United States, that, while railroads are now, as they were originally, operated, so far as their internal affairs are concerned, as private companies, yet, in the service which they render, they are considered to some extent as public in their character, and subject, so far as this public service is concerned, to reasonable regulation.

This regulation having destroyed special privileges, and having put all persons and communities upon an equality, a much better understanding has grown up between the railroads and the people, and my experience leads me to the opinion that here in Iowa the courts, city councils, legislatures, and public officers, and the great body of the public, desire that these important interests shall receive equitable and fair treatment.

In a general way, the authority of government regulation, as applied to common carriers, is limited to the following propositions:

1st. Requiring reasonable and uniform rates for the carriage of passengers and freight.

2nd. The prohibition of discrimination as between persons and communities similarly situated.

3rd. Such reasonable police regulations as refer to the health, comfort, safety and convenience of the traveling public, and the residents of localities through which the line passes.

4th. The exercise of these powers must be reasonable, and the reasonableness of carriage charges must be measured by what is fair compensation for the service performed, which includes a just profit on investment over carriage and maintenance charges.

5th. The exercise of power and authority by the state or federal government, through legislative bodies and congress, is not an arbitrary power, but is subject to review by the courts, and will be declared void whenever constitution or contract privileges have been violated, or when there is an unreasonable or arbitrary exercise of power.

It must not be considered that an act of the legislature or an act of congress is a panacea for all ills which an individual or a community may complain of. Legislative bodies will not ordinarily consider technical, meritless, or individual grievances. The legislature will generally make a mistake when they attempt to control the details of the management of any business. The art of operating and maintaining a railroad has become a science. The business of railroading is a profession. The correction of errors in the ordinary details of the management of the business of a large railroad must ordinarily be left to competition, and, while the oganization of great systems and the government control as to reasonable charges has eliminated competition as it was once defined and recognized, yet there is most active competition among the various railroads in the line of prompt service, courteous treatment, and rapid transit. The important element which controls the management of all of these roads is that of safety, and the managers of these large enterprises can be relied upon to adopt all means which tend to minister to the comfort, safety, or convenience of the persons who travel or who ship upon the railway lines.

The officers of railroads, especially those who are at the head of the operating, traffic, and mechanical departments, are ordinarily men who have devoted their lives to the study of the business in which they are engaged. They have reached their prominent positions by an exhibition of merit that is necessary for success in any line of industry. They have become scientific, educated, and accomplished men in their particular line.

Modern managers of railroads fully recognize the interest and the control which the public has in railroad affairs. The creation of Railroad Commissioners has afforded a special tribunal where ordinary grievances may be corrected. Wherever a gievance of merit exists, the railroads are prompt to consider the cause of complaint, and if practicable, remove it, and where the cause of complaint is meritless and groundless, which so

often occurs where a great corporation comes in contact with so many individuals. It is difficult to get legislatures or commissions to consider same.

I believe that the present understanding between lines of transportation and the people is better than it has ever been. I believe the people recognize how necessary to the prosperity of individual enterprise and community advancement a good line of railroad is. I believe the railroads recognize fully the duties which they owe the general public. Upon these lines of better understanding the service of the various roads is being improved, and people are willing to pay for this improved service fair compensation. I know that the managements of the railroads in Iowa are, without exception, actuated by a sincere desire on their part to fully recognize their obligations to the public, and in compliance with these obligations, give fair and adequate service, without discrimination, to the communities and individuals who patronize them. Effort is being made looking to more intimate acquaintance with the patrons and residents on the various lines, and by fair treatment, prompt service, and courteous consideration of just claims, create, foster, and maintain cordial relations between the railway carriers and the public which they serve.

*OBJECT OF RAILWAY ACCOUNTS AND STATISTICS

By J. L. BURGESS, Chicago

"In the mass of figures that make up the returns of railroads we find the measure of their success or failure. It is not probable that the statistics of any two railroads are alike except so far as they are compiled for governmental purposes, and even in the latter case they are only generally alike, because uniformity is impossible—inherent obstacles prevent it.

To understand the statistics of railroads requires infinite patience, attentiveness, perception; the power of thinking consecutively upon dry subjects. These qualities, while not uncommon, are rarely exercised. Men jump at conclusions rather than undergo the fatigue of study. Correct understanding requires continuous, painstaking and exhaustive toil. Statistics are like accounts. The latter cannot be explained, they must be pored over as we would study an algebraic problem. Only men driven thereto or who possess a stout resolution are able to do this. The incentive must be great. Because of this, men

*Lecture delivered at the Iowa State College, October [illegible]

who are not experts devote only such attention to the subject as necessity compels. Want of knowledge in matters of this kind is not considered a reflection upon their industry or capacity; rather the contrary. Because of this those who have charge of accounts and statistics should be moderate; careful to separate the essential from the non-essential; that which can be profitably studied by owners and managers from that which is immaterial. They should, above all things, strive to make their exhibits clear, to avoid burdening them with cumbersome matter that may prevent that which is valuable from being perceived.

Statistics are the electric lights thrown on industrial and social affairs, illuminating the acts of all concerned. The supervision of the owners of railway properties is impossible without this light. Pinching economy, a little money saved by curtailing statistics, may be a shield behind which thousands of dollars will be frittered away. It is impossible to analyze the affairs of corporations without the aid of statistics. The information compiled in this direction has, of course, different values. Many statistics that one company esteems important are omitted without thought by others. Some companies have practically no statistics whatever. I know an instance where a company in straitened circumstances abandoned all its statistics. Generally speaking, however, such action is impolitic. It could not save a company from failing and might precipitate bankruptcy. Under every condition of affairs corporations will do well to maintain full sources of information in reference to their workings. It will induce economy and heighten the effort of managers and employes.

Statistics are conducive to good morals and efficiency.

Much of the statistical information embodied herein is fundamentally indispensable to every company, whether rich or poor, little or big. Without it the affairs of a corporation may be all right, but its real condition can only be a matter of surmise. To say that such a state of affairs is demoralizing in corporate life is to put it mildly.

Some of the tables embrace information that may be termed of minor value. The enumeration is far from complete. Railway statistics are illimitable.

When managers have the time and disposition to study and profit by what statistics tell, money expended in compiling them is well invested.

A necessary concomitant of efficient management of railway property is a thorough and effective system of accounting—one

[illegible] of every dollar earned or spent and sub- [illegible] not spasmodically but uninterruptedly.

[illegible] system of appointing temporary auditors to [illegible] the accounts of railroads at the close of the year [illegible] owners is, in certain respects, a delusion of [illegible] management. It deceives both the owners and the [illegible] that in order to understand the affairs of [illegible] medium of accounts, or to know at least, [illegible] accounts are rightly kept or not, they must be [illegible] from the commencement to the end, item by [illegible] week by week, month by month.

[illegible] go into the office of a railroad at a particular [illegible] affairs. They must be audited as they occur.

[illegible] who does this is the real auditor. Others [illegible] efficient or not, but they must look to him [illegible] the company's affairs. He is its real his- [illegible] auditor. He alone knows whether the conclu- [illegible] are authentic or otherwise.

[illegible] history valuable he must be sufficiently free in [illegible] forward in its discharge honestly and faithfully, [illegible] the right nor to the left, considering no [illegible] otherwise except that of the property. The [illegible] company, i. e., its accounting officer, has nothing [illegible] management. He is merely a scribe. To be [illegible] worthy, he must be largely freed from the [illegible] managers.

[illegible] accounting requires such careful and systematic [illegible] may be necessary to afford a fair exposition of [illegible] expenditures. For the practical uses of the man- [illegible] accountant must carry his analysis far beyond this, [illegible] material and their outlays are concerned. Pub- [illegible] suffice for the stockholder because he has [illegible] nor appliances for probing the subject further. [illegible] management must be thoroughly and systematically [illegible] in every detail, or irregularities will creep in that no one [illegible] otherwise suspect.

The balance of cash or investments thereof that remains in the treasury after paying operating expenses, taxes and fixed charges constitutes net income. This is the goal. Here lies the essence of accounting. It is the duty of the accountant to verify these figures, to certify to their correctness; to gather every dollar of earnings, to see that no dollar is expended that is not duly and properly embodied in the accounts.

Bookkeeping was an afterthought; a device for recording and classifying affairs and preventing roguery. While resulting generally to the great and permanent advantage of business,

the methods were, in many cases, unnecessarily elaborated. This had for its object, originally, a mere scientific elucidation of the mysteries of management. But with the lapse of time, and the opportunities the subject afforded, the primary intent was, in some cases, partially perverted through the efforts of accountants to mystify their superiors and otherwise aggrandize the offices they held. The gratification of the morbid hallucinations that often characterize men of sedentary habits had also much to do with the complications that resulted. However, every day we get onto more solid ground.

Books of accounts are necessary to corporations for the purposes of identifying the money that passes through the hands of different agents. Men who work for corporations must not only be honest, but must also be able to demonstrate it.

When accounts go beyond the purpose of records they become statistical.

Corporations, including governments, are, for obvious reasons, compelled to pass beyond the original or primitive basis of keeping account of what they do and what their agents do. And in this lies the opportunity of the theorist.

So far as the fiscal affairs of a railroad are concerned, the summarization of the balance sheet shows how few and simple are its natural headings. On the debtor side is the cost of the property. But this does not necessarily embrace more than one item. Passing on, separate accounts must be opened with each agent and corporation in the company's debt. Fuel and material need not necessarily be separated; they may be bulked under the head of supplies. On the other side of the balance sheet appear the various classes of shares and bonds. These are succeeded by the current or floating liabilities. The list is closed by the income account, representing the amount of cash, or investments thereof, remaining after satisfying the fixed and incidental charges of a company.

All other accounts (save such as affect particularly assets familiar with the myriad details buried under each of the general or liabilities) are statistical in character and purpose.

This statement will seem like an exaggeration to those headings named in the balance sheet. The explanation is simple: The statistical information of railway companies has become, by long practice, so rooted into their general system of bookkeeping that it is mistaken by many for a fundamental basis. The income item, to illustrate, embodies all the working accounts. It is a summary of receipts and expenditures for the period it covers. All the accounts incident to it are poured into it. It is, in fact, a crucible into which details are dumped

for the purpose of ascertaining results. But before this the details have been passed and repassed through many sieves of different degrees of fineness. Are these latter necessary? Could efficiency be maintained if they were abolished? Why, for instance, are not current receipts credited and expenses charged directly to profit and loss (income account)? Expense would certainly be saved and the service otherwise simplified thereby.

The explanation of current practices lies in the necessity of identifying the items of receipts and expenditures for purposes of reference and comparison, and to demonstrate the fidelity of each agent concerned.

Primarily railway accounts are classified so as to enable owners to judge with intelligence of affairs; itemization affords a basis for calculating the future of the property, and determines generally the faithfulness and intelligence that characterizes the management.

The division of expenses is not of so great importance to managers as is generally thought. It is valuable to them as a resume, generally speaking, they are familiar with each account as it accrues. It is their business to prevent extravagance by anticipating it, not to await its development and exemplification in the returns. If, for instance, they awaited the slow process of accounting before cutting down the force in times of depression, the enterprise they represent would soon become bankrupt.

The attention of managers is directed to the present and future. Their view, generally, is prospective, they are men of affairs, not historical students. And herein they differ from the accountant or statistician, and it is fortunate for the world that it is so.

To the owner of a property, reliable statistics of a comprehensive character are indispensable. Without them he cannot determine its value or the worth of those whom he has intrusted with the management. It is as to the measure of these details, not their general necessity, that differences occur.

As regards the division of receipts practical unanimity exists. The rule seems to be divide earnings into five general classes: Freight, passenger, mail, express and miscellaneous. In some cases, where the transportation of a certain commodity constitutes a large percentage of a company's traffic, the revenue therefrom is shown separately.

The particles that make up the earnings are exhibited in the returns with more or less perspicuity, according to the policy of the company, or the caprice of the statistician. Thus

we frequently see tables exhibiting the direction of the traffic, as through passengers eastward, through passengers westward, earnings from the first class, second class, third class and excursion passengers, number of passengers to and from each station, the earnings therefrom, and so on, the tables following each other until details in regard to each class of receipts are thoroughly explained.

Disbursements involve many separate accounts in the office of the accountant. Some of these are unknown, except to him, and are, in fact, the scales with which he weighs results. They cannot be classified or explained.

The classification of expenses in published returns, if carried too far, has a tendency to confuse rather than enlighten the student. It is of importance, therefore, to restrict the items as much as possible consistent with due intelligence.

So far as correct methods of accounting are concerned, the amount of each collected for receipts or disbursed for expenses is immaterial. Returns of railroad companies should be based on the business done, the amount earned (whether collected or not) and the liabilities incurred during the same period.

Thus it will be seen, through the processes of accounting now in vogue, we have entirely abandoned primitive methods, which looked only to gathering the surplus cash without trying to trace the honesty or efficiency of those handling the business.

Written statistics, to be of practical value to managers, must be simple and easy of access. They are, so to speak, the pulse of a property and indicate the condition of the system whether it is strong and vigorous, or torpid and dull. It should be remarked, however, that the doctor must test the pulse of his patient personally to know its fluctuations and must apply his remedies without delay. It would be of little benefit to a man sick with a fever to have a system of recording his pulse that kept his condition a secret from the doctor for weeks after the tests were made. Railway property occupies the position of such a man. Essential facts in regard to it require to be known as they occur, not tomorrow, but forthwith.

THE UNDERLYING PRINCIPLES AND GENERAL PRACTICES OF ACCOUNTING DEPARTMENTS AND THE DUTIES OF ACCOUNT OFFICERS AND OTHERS CONNECTED THEREWITH.

The evolution of railway practice in America is nowhere better illustrated than in the accounting department. In early days there was no such department. The accounts were kept in the various departments in which the things they treated of

originated. These officers audited the returns and reported the result to a general book-keeper. The freight accounts were kept in the general freight office; tickets accounts in the general ticket office; expenditures in the offices of superintendents, civil engineers, roadmasters, master mechanics and others. The heads of the departments, having matters of greater consequence to look after, gave the accounts little or no attention. Consequently, little or no improvement was made. Confusion reigned, irresponsibility was common and delinquencies frequent and startling. When a fiduciary agent proved unfaithful, those who should have prevented the scandal excused themselves on the ground that they knew nothing about accounts, had no taste for them, and lacked time to look after such matters. This was true. The nearest approach to an accounting officer was the general book-keeper. He entered the results submitted by the different departments, but knew nothing about the technicalities of railway accounts. He was simply a double entry book-keeper and his knowledge such as the book-keepers of merchants and bankers possess. Such a state of affairs could not last. The loose practices it engendered, caused by a lack of concerted effort, technical knowledge and definite responsibility, alarmed both owners and managers. The result was the creation of the accounting department. The first head of this department was the general bookkeeper referred to. Notwithstanding this, it heralded a great advance because responsibility was secured. But the situation was far from answering the requirements of the case. Railroads need bookkeepers familiar with the technicalities of day book, cash book, journal, ledger, and auxiliary records, but in addition to this, they need an accounting officer, who possesses an accurate knowledge of the peculiar accounts of railroads. These accounts are different from all others. No one possessed this knowledge at the start. It was necessary to educate men. The process was tedious and required time. Moreover, the situation was aggravated by the opposition that the concentration of accounts in one department elicited. Those previously in charge of such matters, while they would not give the subject attention or accept responsibility, were yet reluctant to see the accounts transferred to another department. This greatly embarrassed the accounting officer and involved him in many petty troubles that his associates were happily free from. However, the necessity and value of the accounting department more and more impressed itself upon owners and managers so that in time it became a firmly established fact. Its importance did not grow less with the lapse of time— on the contrary it has grown greater. It affords the only authentic means owners and managers have

of ascertaining results. It is the only department that has the time and skill to enforce faithfulness and efficiency in the collection and disbursement of railway revenue. A railway or great corporation cannot be effectively managed without an efficient accounting department. Of this there is now no question.

The devices used in connection with the accounts and financial affairs of railroads whereby business is facilitated and expenses lessened, are equal to the combined devices of all other departments, so far as numbers are concerned. If the old fashioned methods of merchants and manufacturers were used by the accounting officers of railroads, the revenues of these properties now divided among stockholders, would in the majority of cases, be required to meet the expenses of accounting. The growth of corporate life has elevated the handling of accounts from a petty vocation to an active and progressive science; this science is a part of corporate life, and without it that life cannot be perpetuated or carried on even momentarily with safety.

No man has ever yet been able to say with truth that he has fathomed the intricacies of railway management so that he had nothing further to learn. It is a science, and each of its branches possesses problems peculiar to itself, requiring for their elucidation years of thoughtful study and practical acquaintance; and much of this knowledge when acquired at the expense of so much time and patience, cannot be taught or explained.

The number and character of assistants the accounting officer requires will depend upon the nature and extent of the work, but in any event they must be skilled in the technicalities of their duties. He will require a particular corps of workers devoted to passenger receipts; another to bookkeeping; another to inspection work at stations and elsewhere. If the accounting officer has supervision over both the accounts and local finances, as is sometimes the case, he will require on his staff such cashiers, clerks and paymasters as may be necessary to perform the work.

It is of the greatest importance that those in charge of the various bureaus of the accounting department should possess especial fitness for their work. They must be skilled by long years of experience; must know the scope, possibilities and limitations of accounts. They must also be familiar with the methods of other companies, so that by comparison and otherwise they may be able to determine what is best.

No officer of a railroad, it may be said, is more dependent upon his assistants than the accounting officer, and no one

more requires capable and trustworthy men than he. Without them he will be without ability to supervise and execute. This is, however, true of every department of a railroad. It illustrates the necessity of building up the service in this direction on an intelligent and permanent basis.

One of the duties of the accounting officer is to make frequent exhibits of the affairs of the company, such statements as are necessary to a full, true and accurate understanding of its business and property. These returns are the mirror in which is reflected to owners and managers, the operations of the property, in detail and in gross; in which they may see the route they are following; the destination they are approaching. The importance of such exhibits can hardly be estimated, in the case of properties so large as not to be within the ken of a particular man from hour to hour, or that are managed by agents.

In devising methods of accounting designed to secure authentic information in regard to corporate affairs, returns must be verified by concurrent evidence; by corresponding statements from other and independent sources. If this is done, omissions and inaccuracies, whether intentional or otherwise, cannot be concealed without collusion, a thing not likely to occur if proper precautions are observed. Herein lies the secret of corporate accounting, and the skill displayed is the test of fitness. The principle that should be observed in organizing and managing corporations generally, namely, independent but concurrent action, should be applied to accounts with reasonable vigor.

The necessity of having the affairs of the various departments of a railroad corporation audited by an independent and co-ordinate department was first strenously advocated by the writer, prior to 1870. The practice is now generally recognized by enlighteded governments, whether public or private. It is the method of procedure enforced by our general government. The accounting officer is entrusted with the supervision of the accounts of all who handle money or supplies. In each department of the government he has an auditor with a corps of assistants whose duty it is to look after the trust reposed in such department. In all departments, save the treasury, the handling of money is an incident only. In the latter it is the principal business. It supplies money to each department on requisitions. Railroad companies call them vouchers. After issuing the money on the requisition of a department, the treasury department follows it up to see that it is properly used. This duty is facilitated by requiring every official to make returns of receipts and disbursements to the

auditor of the treasury for the department in which he is located. The books of the treasury show where, by whom, and for what purpose money is collected; also where, by whom and for what purpose money is disbursed. From this universal knowledge the function of the secretary of the treasury as auditor of every department of the government is made effective. His authority is commensurate with his responsibility and the gravity of the service. The question suggests itself, why did not the government establish a bookkeeping department, pure and simple, to audit its accounts and look after its receipts and disbursements? The answer is, because such a department, possessing only abstract duties and clerical habits, could not make its authority respected. Instead of being able to enforce responsibility throughout the various departments and bureaus of the government, it would have been ignored or evaded. What is true of the government is true of all great corporations. The accounting department needs the invigorating and strengthening assocation that possession of the "strong box" gives it; something potential, that cannot be evaded; that comes within the easy comprehension and experience of every man; that exacts from him compliance with certain rules and regulations if he would get that which belongs to him.

IN REFERENCE TO AUDITING FREIGHT, PASSENGER BAGGAGE CAR AND MISCELLANEOUS RETURNS.

The examination of the freight returns of agents and others is one of the most important duties connected with the fiscal affairs of railroads.

The methods used in auditing such returns (for the purpose of discovering and correcting omissions and mistakes) differ widely. They are, however, all orderly and exhaustive.

Circumstances have much to do with the case.

No matter what the system may be, however, the waybill is the foundation upon which the structure is built. It is the source from which information in regard to all freight traffic is obtained. It is important, therefore, that it should be in evidence and correct. To insure these objects it must be surrounded with safeguards.

Whatever differences may characterize methods of accounting in other respects, it is essential that every waybill should be examined at headquarters. Such examination will disclose more or less errors of classification, rates, extensions, footings, and so on.

The amount of freight forwarded should agree with the

amount received. Thus the tonnage and charges (of each kind) reported by station A as forwarded to station B should correspond with the amounts station B reports having received from station A. If they do not agree, the account should be examined in detail and the difference discovered and corrected.

The abstracts of freight rendered by agents should be footed at headquarters; afterward these totals should be compared with the summary.

When the audit of freight returns has been completed, the balances, (i. e. the footings of various columns that affect the agents' accounts) should be certified to the accounting officer for entry on the general books. Afterward the freight auditor should recapitulate the aggregate charges for local freight forwarded and received, to ascertain whether the amount of freight forwarded agrees with the amount of freight received. In the event the two do not agree he must re-examine the accounts and locate the difference. The accuracy of the accounts is, in a measure, verified by agreement of amounts forwarded and received.

The returns (including the abstracts) of local freight forwarded and received should reach headquarters on or before the seventh day of the month succeeding that for which they are made.

In reference to joint freight accounts with other companies.

Receiving roads prepare and send to the forwarding company abstracts of way-bills received up to the time the account is closed i. e., bills dated prior to the first of the month in which the statement is rendered. They are accompanied by division sheets showing each road's proportion of the earnings, also balances due. All intermediate roads interested are also furnished with copies of the abstracts and division sheets. These abstracts and division sheets are forwarded so as to reach their destination not later than the eighteenth of the succeeding month, unless some other date may be agreed upon. If, for any reason, reports are not forwarded in time to reach their destination on the date stated, the receiving company notifies the forwarding and intermediate companies by telegraph (on the date specified) of the amounts of their respective proportions, balances due, and so on.

The abstract and division sheets constitute in every case the basis of settlement between interbilling companies.

All balances are settled by draft on or before the twenty-fifth of the month.

In settling the receiving road pays to intermediate companies their proportions of the business, regardless of whether

the charges are prepaid or not, prepaid charges and advances being arranged between the forwarding and receiving roads.

One of the duties of the accounting department of a railroad is to see that the revenue from tickets is duly accounted for. To facilitate this the ticket auditor's office is created. It is an auxiliary arm of the service, aiding in the collection of earnings and the prevention of impositions. It affords, among other things, protection against the introduction and use of duplicate or fraudulent tickets, and is intended to compel the prompt reporting of tickets sold by agents and others. The office is indispensable to every company.

By making free use of the information gleaned by traveling auditors and with the aid of many curious and subtle devices, impossible to enumerate here, but at once effective and economical, and which will readily suggest themselves to accounting officers, the ticket auditor may throw around the issue, sale and accounting for tickets safeguards that cannot be attained in any less practical way.

One of the most important features of the ticket auditor's office is the collecting, arranging and auditing of the ticket and other tokens collected from passengers. The work is simple but very voluminous in the case of a big road. Some of the primary details observed may be noticed. In the first place those engaged in the work should learn the name of every ticket office and the order in which it appears, and on what division, so that they will know its location without having to refer to the list of stations. This knowledge is necessary to enable them to work rapidly and accurately. They must also learn the name of every railroad.

In assorting and examining tickets, they are required to keep a sharp lookout to see that tickets are properly cancelled and when not so cancelled, to correct omission.

Immediately upon receipt of the ticket reports and returns the work of auditing the same commences. The process cannot be accurately described. The most labored analysis is observed. The figures examined, compared, footed, and finally after being found correct are posted upon the journal used by the general bookkeeper.

When accounts are audited monthly, returns of tickets sold by agents should reach the ticket auditor by the first train after the close of the month. If in auditing returns an error is discovered, notice of the fact is forwarded to the agent or company making the mistake.

In reference to balances due from agents for local ticket sales, the amount is certified to the accounting officer upon the

agents' ticket journal after the returns have been audited. The process is very simple. However, the tickets reported as sold are compared with the tickets collected.

Sometimes tickets, after being stamped or having the destination inserted, are not used. In such ways many tickets are spoiled. Across the face of such tickets, agents write in ink "void," inserting the date. These tickets are sent to headquarters with the returns.

The amount due from conductors for collections is verified so far as possible by the ticket auditor and certified to the accounting officer on conductors' journal.

In reference to the extra baggage business of agents, returns therefor may be forwarded to headquarters by the first train after the close of the month. As soon as the accounts can be audited (say not later than the nineteenth) balances are certified to the accounting officer for entry on the general books.

In reference to the miscellaneous receipts that enter into the accounts, such as switching, dockage, car services, etc., not shown on freight way-bills, a return may be made of same monthly or as often as agreed upon. A return should also be rendered of amounts remaining in the hands of agents from over-collections, credits, etc. These amounts may be certified to the general bookkeeper on the "Agent Accounts Journal" or separately, as desired.

Amounts due other companies (for the use of cars) are credited in the month in which the cars are used; amounts due from other companies for use of cars are charged upon receipt of the returns therefor. When the transactions for a month are thus passed the balance of the account is struck and the amount drawn for by the creditor company. Notice of the draft is not required by the great bulk of the companies, the general understanding being that as soon as the balance is known by the creditor company it may draw for the same.

The summing up of freight, passenger and other accounts should be in the hands of the accounting officer on or before the 19th of the succeeding month.

THE MANNER IN WHICH EARNINGS AND DISBURSEMENTS ARE FINALLY FOCUSED ON THE GENERAL BOOKS AND THE ANNUAL NET PROFITS OR LOSS IS DETERMINED.

Profit Or Loss or Income Accounts.

This exhibit embraces on one side the company's current receipts and on the other side its operating expenses, taxes and

fixed charges. It shows, also, any amount there may be available for dividends, or the deficit, if there is a deficit. The balance of cash in the treasury of a company cuts no figure. The purpose of this statement is to show the result of operations. It is quite possible that a portion of the earnings exists in the shape of balances due from patrons and connecting lines. This fact, however, is not material, as the amount has not been earned. In the same way all accrued operating expenses and taxes are included, whether paid or not.

The practice among many American railroads, of utilizing a part of their earnings for improving and bettering their properties, cuts no figure in determining results. The amount applicable for dividends is properly the net after paying operating expenses, taxes and interest. If any of this surplus has been diverted for purposes of improvement, it is purely a question of policy as to its final disposition and, therefore, one that cannot be judged in advance or covered by any formula.

The credits to income, or profit and loss, are embraced under the following heads and include the things specified in connection with each:

Passenger Earnings:—This account includes the gross receipts from passengers, whether carried on passenger or freight trains, amounts received for hauling cars in passenger trains, receipts for accommodations in parlor and other cars, charges for transporting corpses when ticketed the same as passengers.

Freight Earnings:—This account includes the receipts for transportation of freight (not otherwise provided for) whether carried in freight or passenger trains. It also embraces charges for transportation of milk, earnings, (save from passengers) derived from transportation of property of circuses and similar shows; also amounts received for hauling cars in freight trains.

Express Earnings:—This account includes amounts charged for transportation of express matter.

Mail Earnings:—This account includes amounts charged the government for the transportation of mails and messengers, and for facilities rendered in connection therewith.

Miscellaneous Earnings:—This account includes extra baggage charges, amounts for transportation of parcels and animals in baggage cars; credit balances for mileage of cars, credit balances for switching and transferring cars, amounts charged for rent of tracks, buildings, lands, yards and terminals (when same are directly connected with the operation of the road); amounts charged for storage, car service, loading and unloading, cooperage, weighing, charges against news agents, and

other sources connected with the operation of a road not otherwise provided for.

Interest on Bonds Owned by a Company:—This account includes interest on bonds owned by the Company, whether same are held in its treasury or in trust for it by a trustee.

When, however, bonds are deposited with a trustee, in lieu of other bonds issued, they are in the nature of a set-off. In such case, the amount received as interest on the bonds deposited is credited to the account to which the interest on the outstanding bonds is charged.

Dividends on Stock Owned by the Company:—This account includes dividends or interest on stock owned by the company, whether same are held in its treasury or in trust for it by a trustee.

Miscellaneous Income: This account includes interest on notes and loans, premiums on notes or current accounts sold, balance of receipts over payments for exchange, rent of buildings and lands not connected in any way with the operation of the road, other collections from sources not connected directly with the operation of the road, not otherwise provided for herein.

The Debits to Income, or profit and loss account, are embraced under the following heads and include the things specified in connection with each.

Operating Expenses: The operating expenses include cost of working the property and maintaining the same. They embrace the wages of men engaged in conducting the business, including the cost of repairs and renewals and all expenses incident to operating and maintaining.

Taxes: This account includes taxes on real estate, right of way [illegible] and other property, real or personal [illegible] dividends or interest [illegible]

[illegible] the interest [illegible] paid on gold [illegible] necessary to [illegible]

[illegible] Exchange:—This [illegible] and discount [illegible] accounts; [illegible] drafts, checks, [illegible] for.

[illegible] rentals for [illegible] stock or evi- [illegible]

Dividends on Stock:—This account includes dividends on capital stock or evidences of the latter, or substitutes therefor.

Other accounts than those mentioned in the foregoing may be opened as occasion requires to cover receipts or disbursements of an extraordinary nature which may arise in the operation of railroads, and which it is desirable for any purpose to show apart. The foregoing, however, constitute generally all the headings that appear in the profit and loss account.

As will be seen from the foregoing, profit and loss is credited with earnings, less certain petty items in the nature of refunds, drawbacks and overcharges; it is charged with operating expenses, taxes, interest and rentals.

If receipts exceed expenditures the difference represents net income, if they fall short, it represents a deficit.

Dividends are properly payable out of net income.

The income account, it will thus be seen, embraces every current receipt and expenditure incident to the operation and maintenance of the property.

A study of the Income Account shows that everything is finally summed up in this statement. If a dollar is lost, stolen or frittered away it lessens the balance carried to the credit of owners (that is the surplus) just so much. If earnings are honestly collected and expenditures carefully scrutinized, the income account should exhibit the full capacities of a property; otherwise not.

THE GENERAL BALANCE SHEET.

The general balance sheet of a company sums up its affairs and summarizes its accounts. It is a resume of its operations up to date.

A great desideratum in this balance sheet is to arrange and condense the information so that the reader may comprehend at a glance the things it is essential he should.

It should embrace only such information as is of interest to owners and managers, and those who seek investments in the property.

It should be remembered in compiling such a statement as this that too nice particularization of facts tends to befog rather than enlighten.

In this exhibit only the aggregates of the different classes of accounts should be embodied. The details necessary to the elucidation of these accounts can be rendered apart.

A general balance sheet should exhibit on the debtor side

the cost of the property; also its assets, including supplies. On the other side of the statement should be shown the amount of the capital stock, classified, particulars of funded debt, and liabilities of various kinds. Further than this it should not go.

FINANCE.

In the life of a railroad there are three well defined periods of development, namely:

Financing,
Construction,
Maintaining.

Mr. Kirkman devotes ten chapters in volume No. 3 to the salient features of railroad finance and, while it would be exceedingly instructive to investigate the subject fully, it is one which should be given more time than we can spare tonight. However, it may be well to learn something of the different kinds of bonds and shares and the methods governing their issue and payment.

"The total cost of a company's property, including the supplies and working fund required in its operation, is the proper basis of its capitilization. In the United States this is represented largely by mortgage bonds and what is called capital stock. The latter should more properly be called shares capital. The term capital stock in the sense we use it is misleading, because applied to a security that represents only a fraction of the cost.

In England they speak of the capital stock of railways. Never of cost. The former at one time implied the latter.

Every company should be priviliged to cause the cost of its property to be represented either with interest bearing bonds or shares (The English speak of the obligations of governments as stocks, the securities of railroads as shares) any excess of cost over such issues to stand upon the books until such time as the proprietors see proper to give it representation; it is a part of the capital as much as the first dollar paid toward the venture.

Whatever a company earns over its operating expenses, taxes, rentals, interest, and other accounts chargeable against income, belongs to the owners of its shares, to be equitably apportioned among them. It is called a dividend. This division is in many cases delayed. In some instances it is never made, but withheld for use in improving the property. However, it is in the nature of a loan, and should not be covered up

in the accounts nor lost sight of. It is an obligation due to the share-holder, the same as a note of hand, payable when the exigencies of business will permit.

A majority of the shares of the capital stock of a property (or a majority of those voting, according to the by-laws of the company) elect its directors. These control its operations for the period of time for which they are elected. In the event of foreclosure and sale of a property, the shareholders (who are the company) possess the right of redemption, but in the event this right is not exercised, their shares may become invalid.

The par value of a share of capital stock in an American railroad is usually one hundred dollars. In some cases the shares are fifty dollars each. Frequently, two kinds of shares (preferred and common) are issued. Their printed form is substantially alike. They have, however, different rights. The higher grade is called preferred stock or preference shares, the subordinate grade, common or ordinary stock. The right these shares severally enjoy, and the maximum amount of each that may be issued, are set forth in the articles of incorporation and this limit can not be exceeded without the formal consent of the parties in interest.

Many companies have more than two classes of shares. The relation they sustain to each other is determined by the circumstances that necessitated the diversity of interest. When a company in poor credit is compelled to raise money, the best terms it can get are accepted; sometimes mortgage bonds are thus created; sometimes new shares are issued (at a great discount, perhaps), which shares, by consent of the holders of existing securities, frequently take precedence of prior issues. There is no fixed value. It is in such ways that different classes of shares and bonds come into existence. The rights enjoyed by holders of preferred and common shares, on different roads, are rarely the same.

When there are two classes of stock, the preference usually extends no further than a division of net earnings. Thus while the holders of preferred stock may be entitled to a certain return before inferior stock shares can receive anything, still, in the event the property is sold, the surplus, after satisfying the mortgage and other debts, is divided equally among all classes of shareholders. In some instances, however, the rights of the preferred holders extend to a division of the property.

Dividends are declared by the board of directors. The meeting at which a dividend is declared must be legally convened and must in all respects conform to the statutes and the company's by-laws. The amount of the contemplated dividend

being fixed by the board, it declares how it shall be paid (whether in cash, in shares or in bonds) and when. It also fixes the date when the books in which transfers are recorded shall be closed and when they shall be reopened.

Dividends are paid to the order of the persons who appear upon the stock ledger as owners at the time the books are closed.

A period averaging from ten to thirty days usually elapses, between the declaration of a dividend and the closing of the books. The reason is that there are many shares passing from hand to hand (as they are bought and sold) that have not been transferred on the books. When a certificate is sold by the original holder the power of attorney on the back is signed in blank by him. This enables the holder, whoever he may be, to take it to the office of the registrar at any time he pleases and have it transferred. But shares frequently change hands many times without transfer of ownership appearing on the books.

When a dividend is declared, every person who owns a certificate registered in the name of some one else usually (but not necessarily) has it transferred. It is in order to facilitate these transfers that a period of time is allowed between the declaration of a dividend and the closing of the books. While the books are closed details regarding payment, such as the drawing of checks, etc., are performed.

Mankind has only a vague idea of what constitutes a sinking fund. Many who are otherwise attentive to what transpires around them refuse to consider the term at all when they meet it in print.

A sinking fund is something set apart for a particular purpose. It does not necessarily consist of money. We will suppose that a railroad company has certain bonds that will become due at a specified time in the future. To insure the payment of these bonds, a fixed sum is laid aside annually, or semi-annually. The amount thus husbanded can be used for no other purpose whatsoever. It is called a sinking fund.

Frequently no provision is made in a mortgage for a sinking fund. In many cases the creation of a sinking fund is esteemed imperative by investors. The object sought is, of course, to strengthen the security; to insure the fulfillment of all the obligations of the mortgage, including the payment of interest and principal when due. The company issuing the mortgage binds itself to place a specified sum at fixed periods in the hands of the trustee of the fund. Sometimes these payments are in cash, sometimes in bonds of the issue for which

the fund is created, sometimes in other securities. Provision is also made in regard to investing the accretions of the fund, i. e., the interest and premiums that accrue on the amount in the hands of the trustee.

In case uncanceled bonds are deposited with the trustee, the provisions of the fund require that the interest on such bonds shall be collected and added to the fund. Whatever sum the trustee may have on hand when the bonds mature he uses in payment of the mortgage.

To prevent improper use of bonds thus deposited, the fact that they are held in trust should be plainly stamped upon the face.

Sinking funds should only be paid in cash when bonds for which the fund is created cannot be purchased and used in lieu thereof.

In some cases it is provided that in the event sufficient bonds cannot be purchased at a specified price in the market to satisfy a sinking fund, the trustee may draw by lot the number of bonds required, the holders of such bonds being compelled to deliver the same at a stipulated rate. This plan is a very good one, but it is objectionable to the holder of bonds, as it makes the duration of their investment uncertain. Such provision is, therefore, held in the place of a stable security to be undesirable.

Of the various forms of sinking funds, that which requires the keeping alive of the bonds in the hands of the trustee, and the collection of the interest thereon and its re-investment by the trustee, affords greatest security.

In reference to the treatment of sinking funds in the accounts, they are in the nature of unrepresented capital. A sinking fund takes the place of obligations, that at one time represented cost. It has, therefore, the same rights as the original investment; the right to be represented by bonds or shares. It is not chargeable against income any more than any other capital expenditure. The reason why we so often find it included in the income account is because of the conservatism of proprietors. It is another way they have of strengthening their properties. It is similar in effect to making improvements with net earnings. While the practice appears to trench on the rights of stockholders, it is not to be hastily condemned. The fact that it is done by sagacious and practical business men is, in itself, sufficient evidence that it is proper.

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THE IOWA ENGINEER

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ANNOUNCEMENT

BEGINNING WITH THIS ISSUE, THE IOWA ENGINEER WILL BE PUBLISHED BI-MONTHLY INSTEAD OF QUARTERLY

BUSINESS ENGINEERING

That the technical education furnished so generally to the youth of this country is meeting a real need and producing real benefits to the country at large is conceded by all thoughtful people.

This broad statement applies especially to engineering education. Nevertheless, there is evolution in the curricula of engineering schools which is the natural result of experience in teaching by the faculties, experience in gaining and holding recognition by the graduates, and experience by business men, corporations and bureaus and departments of government who employ engineering students in positions of trust and responsibility.

With engineering education thus passing in review, as it were, before so many critical eyes, it would not be remarkable if now and then some one peculiar feature of this new education, perhaps a weak feature, should receive a large and concentrated share of thought and criticism. As a matter of fact the technical journals and the transactions of the engineering societies give considerable space, first to one and then another special phase or detail of engineering education. For example the Society for the Promotion of Engineering Education has for [illegible] years been discussing the subject and [illegible] has assisted in the evolution above referred to. Important questions

of policy, of ideals and of methods have been raised, settled or deferred for further light or experience.

For several years the writer has been impressed with the fact that the engineering graduate is woefully deficient in acquaintance, not to say knowledge, of the principles underlying ordinary business transactions between individuals, corporations, etc.

To say "woefully" deficient is not a bit too strong, because in this day and age the successful engineer, i. e. the man who is a constructive engineer in the broadest sense of the words, must be a man of affairs in order to handle the financial problems as well as to supervise the business details with which his engineering practice will most certainly be surrounded and permeated.

At the same time the writer has realized and realizes now that much of the business training of the engineer and his consequent strength as a man among men must be the outgrowth of experience and environment outside of college and campus.

But it is also a fact, recognized by those who know the capabilities of engineering graduates, that the engineering curricula do not, in general, prepare the student for immediate usefulness, that his professional proficiency is the outgrowth of more or less drudgery in the mastery of details of the particular line of work which he pursues after graduation and that the time thus spent in getting acquainted with his world will depend upon his natural personal qualities, such as honesty, tact, executive ability, etc., and upon the thoroughness with which he has imbibed or has been imbued with the principles of the sciences underlying his profession and upon the mental discipline generally of his college course.

"The principles of the sciences underlying his profession," is the real key-note of the technical curriculum. Now, business is a science and an art, and it underlies the profession of the engineer. Therefore, may not the inculcation of its principles be given a place in the college course of the engineer?

The writer would answer this question in the affrmative and he does not stand alone. But it is much easier to answer "yes" to the question than to establish satisfactory courses of study in "business engineering."

The obstacles are (a) the present overcrowded curricula, and (b) the inherent difficulties in the presentation of the subject in an attractive or suggestive, and consequently in a truly valuable way to the students.

Obstacle (a) is readily overcome if we admit, as we must, the importance of the business side of engineering, and a place can be made if obstacle (b) can be overcome.

At Stevens Institute of Technology there is a Department of Business Engineering, and the attention of the reader is called to the way in which the difficulties of the case have been met at that institution as presented by its president, Alex. C. Humphreys, who is also an alumnus of the institution and an engineer of large business as well as professional experience.

*"As in schools of engineering we cannot expect to instruct the students in all the specializations of engineering science and practice, so with instruction in business methods we can expect to give only a broad training in fundamentals upon which the student can safely and expeditiously build when the need for specialization is encountered.

"If it be admitted that the engineer-student should receive some instruction in business methods before graduation, it then remains to be determined what can be added in this connection to a course already crowded almost to the limit. Perhaps the matter of first importance is accounting. We cannot expect to train the students to be expert book-keepers, nor is it necessary to do so; but we can expect to give them what is of more value and what many book-keepers do not possess—a sound knowledge of the principles of double-entry bookkeeping. This knowledge engineers need to enable them to exercise a close, intelligent and independent supervision of manufacturing cost.

"The students should be taught to carefully and conscientiously discriminate between the charges to capital or revenue, and they should be warned of the ease with which errors can be made in this connection and the disastrous consequences likely to follow their commission. They should also be shown the necessity for making adequate provision for depreciation of plant, the scheme to be based upon an exhaustive analysis of local conditions and not upon the blind acceptance of arbitrary rules formulated by accountants. They should be shown that books can be so kept, either through ignorance or design, as to hide the facts and to present a warrant for the payment of dividends unearned. They should be shown that all this, and much more, they will need if they are to be competent as managers or reliable as advisors in connection with the purchase of properties.

"They can also be shown that often, when called in to pronounce on the value of some new apparatus or process where these have already been under commercial test, the technical investigation may well be supplemented by a competent examination of the books of account; and that here the man who is only an engineer or only an accountant will probably be found incapable of conducting such an examination. In such a course

*Reprints of Lectures and Papers, p. 52. Dept. of Business Engineering, Stevens Institute of Technology, Hoboken, N. J., 1903.

might also well be included enough instruction in the science of statistics to warn the student against the danger of drawing conclusions from insufficient or inconsistent data.

"In connection with the work in this and other departments the effort should be made to bring the students to a keener appreciation of the value of a working command of English. They should be shown that it is not enough that they possess the knowledge, but they must have the ability to convey to others, and especially to their clients, in language concise and free from ambiguity, the results of their professional or administrative work.

"Unquestionably there is a crying need for more efficient work in the teaching of English in the schools of technology, and perhaps this statement may fairly be extended to include some of the colleges and universities. Reform in this direction is most difficult of accomplishment. The work performed is too often of a perfunctory character, whereas it should be characterized by enthusiasm and originality. The time available is limited, and, therefore, the first care should be to give such a training in English as will be most efficient to meet the requirements of professional practice.

"This leads naturally to another feature which may well be included in the department of business methods—instruction in the law of contracts. We cannot expect to give engineer-students a working knowledge of the law of contracts, but we may very reasonably expect to impress them with the dangers to be encountered and the necessity of knowing when it is advisable to seek thoroughly competent legal advice. Some advice in this line can also, to advantage, be included in the lectures on engineering practice.

"At Stevens Institute of Technology a course in business methods was started in 1897, though it was not until two years later that the work was put upon a firm basis. At first a number of engineers and bankers gave a series of lectures to the Senior Class, to point out by examples from their own professional and business experiences the necessity for the engineer to recognize that his work must be in accord with commercial practice. Two years later ten lectures on accounting were delivered to the Junior Class; but as this work was left optional, the students derived little benefit from it. For the last three years the course has included twenty lectures and recitations, followed by regular examinations. It is believed that this course has been of real value, and could have been of far more value if the students in the first few lectures could have been brought to believe that this is a subject which properly belongs in a course in engineering.

"Now this part of the curriculum has been again carried forward to the senior year. It is hoped and believed that from now on this feature of the curriculum will be of much greater value to the students because the first few lectures will be delivered by successful engineers and business men who have in their work demonstrated the necessity, or at least the advisability, of such training. It is believed that the students will be ready to accept such testimony and act upon it where they would not do so if the advice were offered by professional educators or accountants.

"As it is important that the first year's class should be promptly impressed with the practical necessity for such a knowledge of English as has already been spoken of, a few talks will be given to the entering classes to bring them into a more sympathetic and receptive mood toward this and all other non-technical studies included in the curriculum.

"Generally the entering class in their wisdom are ready to promptly denounce as useless or out of place these non-technical studies; thus the sympathetic co-operation of the students, which is such an important element in the efficient teaching required in a full course of study, is not obtained, and the foundation is laid for many regrets to be experienced in the years after graduation."

*RAILWAY SIGNALING

By L. R. CLAUSEN

Signal Engineer Chicago, Milwaukee & St. Paul Railway

The advent of the railway locomotive created, without doubt, an impression that some kind of signaling device was necessary to govern the movement of the locomotive over the lengths of its railroad. This impression, while vague, in the beginning, must necessarily have been strengthened into a conviction when two locomotives were first started running on the same road. I say necessarily with good reason as it is a basic principle that the drivers or operators of locomotives hauling trains, whose direction of motion is definitely limited by the location of rails upon a roadbed, must have certain information for their guidance, and this information can best be conveyed by means of some signaling device.

Under ordinary circumstances we do not meet with this contingency in other vehicle traffic, as the driver of one vehicle can turn out to allow another to pass. Your locomotive engine, however, is restricted.

You undoubtedly all have at some time had an experience like this: While driving you have reached a point in the road

*Lecture to engineering students at Iowa State College, October 26, 1905.

where for some distance it was impossible for two carriages to pass. Before entering upon this section of road you have observed a carriage approaching from the opposite direction and about to enter on the same section. Acting upon the usual courtesies you and your fellow-traveler both stop and immediately put into effect a crude block system. After some shouting and much waving of arms one of the carriages has been given the right to cross what might be called the single track section.

This is exactly the condition that obtains at all times upon railroads, where the movement of cars must be within circumscribed limits and in different directions.

Of the two principal reasons giving rise to the necessity of establishing signals for government of trainmen, the first is the probability of the presence of a second train on the same track, and the second relates to the continuity of the rails themselves. The two conditions referred to do not by any means represent all that the railway operating officials would have our fixed signals provide for, and a new condition, calling for more information to be communicated to the locomotive driver at long range, seems to arrive every few months.

From this humble beginning railway signaling has developed until now it is the prime factor in the safe movement of trains over many thousands of miles of road. Without extended research, our conception of the beginning of railway signaling must be more or less in the nature of a surmise as the recorded history is meager indeed, and I wish to state right here that it is not in any manner in keeping with the importance of signaling as a branch of railway operation.

Much of what we now know in regard to the early construction and methods of doing work is tradition handed down by one mechanic to another and it was the common practice for signaling mechanics to build a fence about their information which they had obtained by practical experience. This led to more or less mysterious views of the matter of signaling.

From the beginning of the use of signals up to the year 1840 there had been developed a vast number of fixed targets, vanes and other signals of indiscriminate shapes and colors, apparently of as many designs as there were men engaged in the work. The then existing variety with the prospective future infinite variety brought forcibly to the attention of English railway officials the necessity for the adoption of a standard form of signal for railway service. The semaphore design suggested by Mr. C. H. Gregory was adopted and made the standard in 1841. This date is generally accepted as the first authentic and official appearance of the semaphore in railway signaling.

That our forefathers builded well we must admit and honor them for it, as to this day we have been unable to suggest any improvement on the combination of vertical mast and arm—or semaphore as a railway signal. As may be expected, there have been various small improvements in the method of operating, night indications, etc., but the general design is practically the same today as first adopted. There is just one point, however, where our predecessors erred. The downward inclination of the signal arm was made the clear or proceed indication. If they had made the upward inclination of the arm the clear indication, half of the obstacles with which we have had to contend would be wiped out of existence.

It is an underlying and fundamental principle of all signal work that in case of derangement of apparatus no dangerous condition must arise and that in the event of disconnection or breaking of a signal connection the signal must gravitate to the stop position. To move to the stop position the signal arm must move away from the earth which entails an overbalancing by counterweight sufficient to provide against any contingency that may arise. Thus, year in and year out, we must operate thousands of overbalanced signal arms, because some day an arm will become disconnected during a snow or sleet storm and acquire additional weight. This is a brief reference to one of the various reasons why the upward inclination of the semaphore arm should have been made the "proceed" indication.

The word semaphore is of Greek origin and means to bear or transmit a sign. The term was applied to the combination of an upright mast and a horizontal or inclined arm probably centuries ago before it was adopted for use in railroad work, as we know of semaphores being used in the 16th and 17th centuries as a means of long distance communication. These early semaphores were of a "T" shape and were erected on hills and towers so as to be visible for long distances. A code suitably arranged to conform to the various positions of the arm afforded a rapid and convenient method of transmitting information over considerable distances. Semaphores of the same shape and general appearance can be seen at several non-interlocked crossings and cross-over points on certain eastern roads at the present time.

Presumably the first devices in the nature of a signal used upon railroads were switch targets indicating the position of the switch points or rails. These were originally, and are today, of divers shapes and colors. We do not, however, at this time class them as signals in the usual understanding of the term.

The second probable use for signals was for blocking or maintaing a space interval between trains on one track. A block, as referred to in connection with railway operation, is defined by

the American Railway Association, which is generally conceded to be the American authority in such matters, as follows: "A length of track of defined limits the use of which by trains is controlled by block signals."

A block signal is defined as "A fixed signal controlling the use of a block." A block system is a series of consecutive blocks.

In England the idea of maintaining a space interval between trains seems to have developed from the first beginning of train movement. Signals were used for blocking purposes before the invention of the telegraph, and information was transmitted from station to station by means of electrical instruments of the galvanometer order, the operators interpreting the deflections of a needle suspended in the field of an electro magnet.

The obvious advantage of operating a number of switches by means of levers concentrated at one central point led to the adoption of the semaphore for interlocking purposes, the signals being required to govern the movements of trains over switches so operated. The word interlocking is used, as the levers of such a plant operating the various switches, derails and signals, are so interlocked mechanically that their movements must follow one another in a predetermined order. When a signal is cleared for a train to proceed through an interlocking plant it should mean that all the switches over which that signal governs are properly set and locked. It also should mean that all signals for opposing routes are locked in the normal and stop position. Additional protection, if desired, may be obtained by adding derails and by interlocking opposing signals over the same route so that signals for one direction lock those for opposite direction in the normal position. By using derails for protection of all fouling points, it is possible, when they are closed or the rail made continuous for one route, to lock up the derails for all opposing or fouling routes, so that a train on the first route can not be fouled by a second train.

The derail is advocated by some engineers as a method of enforcing obedience to signal indications, but it is very doubtful if their use is justified, except at main line crossings of two different companies or on sidings where cars might be moved through other than human agency.

There is a tendency at present to eliminate the use of derails largely, and rely on the superior discipline of trainmen. They are used to a very limited extent in the British Isles, on the Continent, and in the eastern part of the United States. Their most general application is on the lines west and northwest of Chicago.

When levers were first grouped for the operation of a number of switches and signals from a central point, each was independent, and, after several accidents caused by mistakes of lever-

men in setting the switches for one route and the signals for another, the necessity for some form of locking between the levers was apparent.

This interlocking of levers can be accomplished in many different ways, the simple and obvious way being to so fit metal dogs between the levers, or bars attached to the levers, that the movement of one lever would drive the dog into a recess on another. This method of interlocking levers permitted of a heavy strain being placed on the locking devices, which were necessarily small and of light construction because of the number of levers to be provided for in a limited space, which led to the invention and permanent adoption of the preliminary or latch locking.

In preliminary locking the first movement of the latch which allows a lever to be moved causes the locking bar or dog to move through one-half its stroke and the final movement of the latch which holds the lever in the reversed position completes the stroke of the locking device. There is no movement of the locking device during the stroke of the lever itself. For instance, the first half stroke of locking bar attached to a signal lever locks mechanically all levers that are to be locked when the signal is reversed and at the final half stroke the former locking is maintained, but levers whose movements are to follow are released.

The development and introduction of signal apparatus in England kept pace with the growth of the railroads, and in the early seventies when interlocking plants were first built in America, they were extensively used in that country. There were in this country previous to 1870, as in the earlier days in England, many forms of signals in use but they were all of the nature of block or warning signals more or less isolated in location and little, if any, attempt having been made to locate them at regular intervals. The year 1870 for all practical purposes can be said to mark the beginning of our signaling history.

The two usual general classes into which signals may be divided are block and interlocking signals. While the first to be used in this country were block signals, I will first review the interlocking, as their development has been somewhat more regular.

The credit of the introduction of interlocking signals in the United States is due to Messrs. Toucey and Buchanan of the New York Central railroad, the former general superintendent and the latter superintendent of motive power. They devised an interlocking machine and installed the first American plant at Spuyten Duyvil Junction on the outskirts of New York City in 1874. This machine compared very favorably with the earlier machines made in England, the birthplace of interlocking, and remained in service until 1888.

The Pennsylvania railroad was also early in the field and imported a machine made by the English firm of Saxby and Farmer, which was erected by English mechanics brought over for the purpose. This machine was placed in service at East Newark Junction on the New York Division of the Pennsylvania railroad on February 11, 1875, and remained in service until sometime after 1889, the exact date of renewal I am unable to obtain.

To show the relative progress of interlocking construction in the United States and England at this time, the following statement may be of interest. In 1875 there were on the London and Northwestern alone 1,400 interlocked levers, while in the United States there were probably not more than 100 to 125.

The firm of Saxby and Farmer exhibited at the Centennial in 1876 a very complete model of an interlocking and block apparatus, and this exhibit did perhaps more than any other one thing to acquaint railway officials of this country with the system then extensively in use abroad.

Shortly after this the elevated roads of New York City were built and equipped with Saxby and Farmer apparatus as manufactured by the Jackson Co. of Harrisburg, Pa., who had purchased the patent rights for this country.

In 1876 and 1877 the Pennsylvania Railway Co., built a few machines at their shops but this was soon abandoned as they found it cheaper to buy of the Signal Companies who were then entering the field.

Slow progress was made in the introduction and application of signal apparatus until 1887, when the demand of increasing traffic made necessary its more general use.

In the early days of interlocking in the United States, there were but three machines in the field. The Saxby and Farmer, manufactured by the Union Switch and Signal Co., and the Stevens as made by the National and as made by the Johnson Signal Companies. They were all alike in regard to the principle of latch locking, the essential difference being in the position of the locking on the machine. In the Saxby and Farmer machine, the locking was horizontal and placed above the floor of interlocking tower back of the levers. In the two latter, the locking was placed in a vertical plane under the floor of tower. The Johnson Signal Company also placed on the market a machine in which the power for moving the different functions of the interlocking was transmitted by means of large wheels fitted with hand spokes. These machines did not find much favor on account of mechanical defects and slowness of operation.

The three machines, National, Johnson, and Saxby and Farmer, are practically the same today as when first placed on the

market. Nothing has been done in the meantime to change the general design of the machine, but, on the other hand, much has been done towards standardizing of the parts. This work has been carried out with such completeness that now all parts of either machine are interchangeable with like parts of any machine of the same type.

With the installation of signals governing movements over switches to diverging routes came the apparent need of giving to the locomotive driver information as to what track his train was to enter on. This led to the application of two arms to a signal mast located at a switch for two diverging routes. It followed that where three routes diverged, three arms were necessary and likewise for any number of diverging routes. This method of signaling diverging routes was used for some time, the tracks for which the arms governed being indicated by making the upper arm read for track to extreme right and second arm for the next track and so on down the mast.

The complication of parts, the chances for accident by improper interpretation of the indications at night when the trainmen are least positive of their locations, and when they should, if possible, receive the most precise information, and possibilities of a light being out caused a general abandonment of this standard.

The next step was to make the upper arm the main line arm in all cases. This simplified matters much, but the complication of lower arm still existed. The multiplicity of arms was finally abandoned to reduce expense and remove the necessity of forcing trainmen to memorize locations, the latter of which was found impracticable.

The next step was to place but two arms to a pole making the upper arm the main line arm as before, and the second and lower arm read to all diverging routes. This lower arm, however, was supplied with indicators which would indicate by a number displayed which route was set up.

This method of signaling was used up to 1890 when practice determined that the indicators were wholly unnecessary and only caused delay due to the men forgetting track numbers, etc. The indicators were discarded and the responsibility for running the train on the right track was put upon the leverman. Under the new condition the locomotive driver could do but three things, i. e., proceed if he received the high arm, run slow if he received the low arm, and stop if neither arm was cleared. If he entered upon the wrong track nothing more serious than a delay could occur.

That the last change was justified and based on good logic may be inferred from the fact that up to this year it has been satisfactorily applied at several thousand plants and has been the

standard for twelve or fourteen years. The ever increasing density of traffic and complication of track lay-outs has within the last year forced upon us the question of making another change, not as radical as the former ones however. At various points heretofore it has been both advisable and expedient to place three arms on one signal mast on account of there being two main line routes and one or more unimportant, and thus relieve trains on the main line of secondary importance from slowing down unnecessarily. In order words, the arms on the mast have in the past and do now generally relate to the importance of the routes governed, the highest arm being for the route of most importance and the second for route of secondary importance, and the third for all other diverging routes.

In many cases the relative importance of a route does not agree with the relative permissible speed over it which makes it desirable to establish an indication which can be interpreted not only as a permission to proceed but to a certain degree as a measure of the speed at which the movement can be made. This brings us to the adoption of a method of signaling speed only, and I may add that this seems to be the most logical of any of the suggested schemes for route signaling which has been advanced to date.

Under this method the high arm of a semaphore pole will govern the high speed route and the other arms will be located on the pole at heights corresponding to the relative speeds permissible over the other routes signaled.

I now wish to describe very briefly the main parts that go to make up an interlocking plant.

TOWER.

The interlocking station, improperly called tower, is in the large number of applications, a two story building of wood or brick, the upper story of which is about 12 feet above the rails and is reached by an outside stairway. The upper story contains the levers of the interlocking-machine, the frame of which, in the mechanical type, is flush with the floor line. Power interlocking machines do not require as much space as the mechanical, and are all above the floor line and resting upon the floor, very much in the same manner as a counter or heavy table. The body of the mechanical machine is below the floor line and rests upon a substantial frame work in the lower story.

Interlocking machines are operated from the second floor of the building to afford the signalman a good view in all directions, and for the same good reason the second story is very liberally supplied with windows.

LEAD-OUT.

Where power machines are installed no importance is attached to the lead-out as the power for operating switches and signals is conveyed through wires or pipes which can be run in almost any manner desired. With mechanical machines, however, this becomes a more important matter, as the power is transmitted through the medium of bell cranks, rocker shafts and moving pipes and wires, and special provisions must be made to bring the pipes and wires out of the building.

Lead-outs for mechanical machines are generally classed under two heads, crank and rocker shaft, respectively. With crank lead-out the vertical pipe from the lever is attached to a vertical bell crank in a frame fastened by bolts to the lower floor of the building from which a horizontal pipe leads out through an opening in the front wall to a horizontal bell crank secured to the heavy frame work of lead-out in front of tower. In the rocker shaft lead-out the vertical rod from the signal lever is attached to an arm on one end of a hexagonal steel shaft extending through front wall and resting in horizontal bearings secured to the floor of lead-out as in the case of the former.

PIPE AND WIRE LINES.

The various pipe and wire lines to the switches and signals lead from the station either directly away or at right angles to the right or left. There are, of course, special cases where this is not the case. The pipe lines are of 1" heavy iron pipe of 16 feet lengths, joined at the ends with an extra heavy screw coupling and further strengthened by the use of a pipe slug which fits snugly in the ends of the pipe and is riveted to each section by $\frac{1}{4}$" wrought iron rivets.

The pipe lines are carried on pipe carriers of the anti-friction pattern placed on foundations spaced 7 feet centers and all turns and angles are, as a rule, made by the insertion of bell cranks and solid wrought jaws fastened to the ends of the pipe lines. A standard $\frac{7}{8}$" pin with a square head and drilled to receive a 3-16" cotter is used for all such connections.

The wire lines are run in small sheaves or wire carriers screwed to the top of wire line stakes which are set in the ground about 2 feet. Where the wire lines extend along parallel with pipe lines the wire carriers are usually secured to the pipe carrier foundations.

Where pipe and wire lines are installed in the open air without cover, and exposed to all the extremes of heat and cold which this northern climate is capable of producing, [illegible] some method of taking care of the excessive variations in length due to

expansion and contraction is necessary. This condition was met by our predecessors and the devices we have in use today for the purpose have undergone practically no change for the past 15 years. For compensating pipe lines the "Lazy Jack" compensator, a combination of two bell cranks on one crank is used. For wire lines there are various devices on the market and various others which have been tried and abandoned. None of these, however are very satisfactory and the majority of Signal Engineers do not advocate their use.

OPERATING DEVICES.

Pipe connected signals are operated by the simple method of placing a bell crank at the bottom of the signal-mast, changing the horizontal motion of the pipe line to the vertical motion of the up and down in such a manner as to cause the signal to be cleared by an upward stroke of this rod. By this means the weight of the vertical rod is added to the counter-weighting of the arm-plate casting to bring the arm back to the horizontal position.

Two No. 9 steel wires are used for the operation of each wire connected signal, one known as the down pull or clearing wire, and the other as the back pull. All turns in the wire line are made by inserting a piece of ¼" wrought chain in each wire at the turn which bears on a cast iron chain sheave properly supported. The wires are turned up at the signal mast in the same manner and attached to the opposite ends of a rocker called a balance lever. This lever, in turn, is pipe connected to the arm-plate casting.

Derails and switches are operated by switch and lock movement and facing point lock connections. When a switch is operated with pipe line connections the movement of the switch points is effected by means of one pipe line and lever and the locking of the switch is by a lock plunger connected to a second line and lever. This is the standard method of operating switches mechanically and [illegible] modern practice.

The switch and lock movement was designed to effect the [illegible] of one lever and pipe line. This [illegible] an overloaded and heavy work- [illegible] pipe line is limited to 12 or 14 [illegible] the locking plungers through the [illegible] switch must be small in comparison with the

facing point lock. The use of the switch and lock movement is now largely limited to derails which need be locked accurately in but one position and to some few trailing switches.

ADJUNCTS.

One or more of the following adjuncts may be used with an interlocking plant:

1. Distant Signals.
2. Electric Locking.
3. Annunciators.
4. Repeaters.
5. Back Locking.

The first of these adjuncts—the distant signal—is in common use. The second and third are less in evidence while the use of the fourth and fifth is rather limited.

POWER INTERLOCKING PLANTS.

As some of you may know it requires the application of considerable physical strength to operate a switch 500 or 600 feet distant from the interlocking station when it is moved by the usual pipe connections of a mechanical interlocking plant and when several hundred lever movements are to be made in one day there is manual labor connected with the position of Signalman. It is the spirit of the American to use his head to relieve his hands and do all arduous labor by machinery as far as possible and to this we owe our power interlocking. While England gave us our first ideas on mechanical interlockings, we have the credit of the development of the power plant being by many years the first in the field.

The first power plant, a pneumatic, was put in service at the Centennial tracks in Philadelphia in 1876. In the year 1880 another kind of plant, hydraulic, was put in service at Wellington, Ohio. Still another, the Hydro Pneumatic, was put in service at Bound Brook, N. J., in 1884. From this time to 1890 there were no new developments in power plants to speak of.

In 1891 a new kind of plant was introduced and put in service on the B. & O. S. W. at East Norwood, Ohio. This was the Taylor electric system and which has since become one of the most important of the power systems. In 1893 some improvement was made in this system and in the seven years to 1900 a few small plants were installed. Since 1900 the Taylor system has been applied to some of the largest and most complicated crossings in the country.

In 1891 the electro pneumatic, which has proved to be the most satisfactory of the power systems from that time up to the present, was installed at the Jersey City terminal of the Pennsylvania R. R. This system has since been put in service at most of the large interlocked terminals of the country.

The last few years has brought out still another system, the low pressure pneumatic. This is much the same as the electro pneumatic except that the controlling force is air, the release indication being given by air pressure. The operating pressure is 20 pounds per square inch.

In the electro pneumatic, as well as in the low pressure, the power for operating switches and signals is compressed air, but electricity is used to control the valves and to give the release indication.

In the Taylor System, electric motors are used to operate switches and signals and are controlled by switches in the tower. The release indication is given by a motor running as a dynamo under its own momentum after having completed a movement.

The three power systems last mentioned are the only ones that have proved a practical success and on account of the large cost of maintenance of pneumatic plants the electric seems to be the one that will be used most extensively in the future.

That interlocking in this country will grow we may infer from the following figures. There are at present in England on the London and Northwestern, a road now operating 1,800 miles, some 36,000 or 37,000 interlocked levers. There are in the United States altogether 42,000 of which more than half are at interlocked crossings. Of the 36,000 on the L. & N. W. nearly all are at yard and terminal stations. If we hope ever to have our roads as well equipped as the average English railroad, there is surely a task ahead of us.

BLOCK SIGNALING AND SIGNALS.

There are three general methods of operation into which block signaling may be divided, viz.: Telegraphic, controlled manual, and automatic. Each of these three methods of operation may be subdivided a number of times according to the actual construction and operation of the signals themselves.

The first method of operation is much the oldest, having been in use in some form for the past fifty or sixty years. Previous to 1870 fixed signals were in use only at isolated points on American railroads but were of the nature of block signals. Up to that time there had been no attempt to locate fixed signals at regular intervals to govern traffic over certain divisions. However, when signals were located for this purpose the first could be

classed under the head of telegraph block. The communication from one block station to another was not always carried on by telegraph as bells were used to some extent at first. In later years telegraph instruments succeeded bells, as information could be more fully transmitted by their use. While the construction and mechanical operation of signals used in telegraph block systems vary indefinitely, the fundamental principle of operation of all is the same, that is, the operator must obtain information to the effect that a block section is clear before he can clear the signal for a train to enter it. There are a vast number of shapes and colors of telegraph block signals in use on the different railroads in the United States, but it is a feature of nearly all of them that they will gravitate to the stop position in case of disconnection of the apparatus at the signal and this principle is carried out in the design and construction of all signals of any consequence.

By making blocks of the sections of track between stations the telegraphic block can be comparatively cheaply installed on any railroad, and this fact, coupled with the increased safety of operation over train order systems, has led to a general adoption of the telegraph system and at the present time it is in use on most of the prominent railroads of the United States.

On some roads it is a rule to have two men work in conjunction to give a train permission to enter a block section which eliminates very largely the chance for a mistake which chance exists wherever the human agent is the controlling factor. The Sykes was the first of the controlled manual system to be used in the United States and except for a few changes in the design to remove certain defects, is the one that is in use today on some of the Eastern railroads. The principle on which the Sykes system works is as follows: A block operator "A," wishing to let a train into a block, notifies the block operator "B" in advance, who, by closing a switch, releases "A's" signal which can then be cleared for the train. The train passing the signal automatically changes it to the stop position by means of an electric slot controlled by a track circuit. Clearing "A's" signal breaks the electric releasing or unlocking circuit which can only be restored by a train running over track circuit just in advance of "B's" signal. There were some features of the original machine which were not satisfactory. One was that it would fail in such manner that a signalman could clear his own signal. Another, though not so important, after signal had once been unlocked, it would be locked up upon being returned to the stop position. To overcome these and other minor disadvantages, the Patenall instrument was introduced and later the Union lock and block system.

In the best installations of both these systems it is usual to extend the track circuit throughout the block to prevent a por-

tion of a train leaving block from releasing the signal governing the same.

All of the above manual controlled systems are applicable to double track only. There are, however, two which can be used for single track, viz.: The Staff system and the Fry and Basford system. The latter works equally well on single and double track, but the Staff system can only be used on single track. The Fry and Basford system is much the same in operation as the Sykes, except that the instruments are of more simple construction and the unlocking is effected by means of polarity of line current and polarized relays. The release to allow of operation on single track consists of making two electric contacts in pre-determined order. None of the manual controlled systems, except the Staff system, seem to be gaining in popularity and but few, if any, machines are being installed.

The Staff system was first put in operation in this country on the C., M. & St. P. R'y in the year 1894 at which time it was in general use in England. The authority for a train to run through a block under this system is a staff in the possession of the engineer. A staff machine is located at each end of the block and it requires the combined efforts of both operators to remove the staff. When a staff has been removed no more staffs can be withdrawn until the first has been returned to either machine. While this system has not come into general use, it is very effective as a means of safely blocking a piece of crowded single track. It is usually operated as an absolute block system but can be operated permissively. The C. N. O. & T. P. Ry. and the Santa Fe railroad are using the staff system on some particularly difficult sections of their mountain divisions and a number of machines are in use on the C., M. & St. P. Ry. The automatic block signal systems may be divided into a number of different classes according to method of operation, power for operation, and the construction of signals.

The oldest form of automatic signal used was the now familiar Hall electric disc and the first application was made on the Eastern R. R., now the Boston and Maine Ry., in 1871. This installation was operated on open circuit plan with track instruments for opening and closing the circuits. The home signals were normal clear, the circuits of these signals only being closed. To guard against possibility of accidents, a second signal called the safety signal standing normally in caution position was placed 500 feet in advance of each home signal. This signal cleared when home signal went to stop position, showing the engineer that everything was in working order.

Within a few years installations of these signals working on same principle were made on the Boston and Albany, Boston and

Lowell, and the Old Colony. The performance of these signals proved that the safety signal could be safely dispensed with by making all controlling signal circuits closed circuits. This was shortly afterwards done, thus establishing a fundamental principle of all electrically controlled automatic signals.

The next development of importance in automatic signaling was the invention of the banner signal, a signal of both form and color. The day indications were given by two discs, one oval and one round, set at an angle of 90 degrees on a vertical revolving axis the motive power for which was furnished by a heavy weight in the body of pole. These discs made one quarter of a revolution at each opening or closing of signal circuit and being of different forms and colors, and having the same back ground, the signal was discernible at a considerable distance. On account of the more or less complicated mechanism and the consequent liability of failure, this type of signal has never been extensively used.

A number of automatic time signals were tried and all were sooner or later discarded. The Fontaine Electric Time Signal was the first of these and operated as follows: The signal consisted of a large dial divided off by numbers from 1 to 15 supporting a hand or pointer which normally pointed to the figure 15. A train, passing, set the hand to O and it immediately began to travel back across face of dial to the figure 15 at the rate of one point per minute. Thus, for any time up to 15 minutes, the hand indicated the number of minutes since a train passed. None of the time signals were used to any extent as they gave but very meagre information concerning the condition of the track ahead and afforded little if any protection.

Between the years 1885 and 1890 the number of accidents occurring on roads where electric signals governed by track instruments were in operation drew the attention of railway officials and signal manufacturers to the insufficient protection such systems afforded and track instruments for operation of signal circuits were relegated to the past. They served a purpose, nevertheless, as without them the cost of installing the first automatic block systems might have dismayed conservative railway officials and the progress of signaling suffered as a result.

After the disc and banner signals had been in use a few years there was a demand for an automatic semaphore signal which could be economically operated. The electric pneumatic signal satisfied this demand to a certain extent but could hardly be called an economical signal to operate. A considerable number of these signals were installed, however, and are giving satisfactory service to the present day.

A short time after the introduction of the electro pneumatic block, Mr. Lattog of the Lehigh Valley Ry. designed and patented an electrically operated semaphore. This signal consisted of a motor fastened to the pole a short distance above a balance lever which was connected by a short up and down rod, to the signal arm casting. A drum geared to the armature shaft carried a phosphor bronze rope, one end of which was fastened to the weight end of balance lever. Rotation of the motor in one direction wound up this rope and lifted the up and down rod clearing the signal. The motor with its gearing mechanism was enclosed in an iron case making its operation comparatively free from failures, but there were so many other working parts exposed that this type of signal could only be operated with safety on the normal danger plan.

The placing upon the market of inside connected electric semaphore signals by both the Hall and the Union Signal Companies served to make automatic signals much more popular with signal engineers and railway officials in general, as it made possible the installation and operation of automatic semaphore signals at a figure which was not out of reach of all but the larger railroads. The only working parts exposed in either of these signals are the arm and arm casting and a small piece of shaft supporting them. This feature makes them equally applicable to normal clear and normal danger method of operation.

The Gray and Herman electric signals have been introduced in last few years and are very much the same as the signals referred to above, with the exception of a few changes in the method of transmitting power from the motor to the arm and in the slot for holding clear. The three position electric semaphore was first worked out by Mr. Gray in his signal and a large number of signals of this type were installed on the P. F. W. & C. Ry. near Pittsburg.

The next automatic semaphore signal to be placed on the market is the Hall Signal Co.'s electric gas signal the first of which was put in service on the Illinois Central R. R. in Chicago early in 1902. The results from the first signals installed have been satisfactory to most signal engineers and at the present time there are some 2,000 in operation or being installed. This signal is a considerable departure from other semaphores in that the power for its operation is obtained from carbonic gas under high pressure, the pressure being reduced by a diaphragm reducing valve to a working pressure of 30 to 40 pounds per square inch. An electrically operated pin valve admits the low pressure gas to a sliding cylinder attached to the up and down rod of the signal which operation causes the cylinder to rise and clear the signal. At a certain point in the travel of the cylinder a trip allows an

arm, also attached to the pin valve, to drop, closing the cylinder to the gas and opening it to the air. At this point the gas in the cylinder exhausts to the air and the signal is held in the clear position by a dog attached to cylinder engaging with a step on a swinging arm at the lower end which is attached to the armature of an electro magnet. The deenergizing of this magnet allows the arm carrying armature to swing out and disengage the dog and signal arm gravitates to stop position. While this type has not been in service as long as other types of semaphore signals, the results so far obtained seem to indicate a bright future for it.

The Kinsman block system was tried experimentally on the C., M. & St. P. Ry. in 1894 and taken out after six month's service on account of failure to operate as desired. The principal reason that this system was not a practical success was that the main electric circuit was an open circuit and a failure to operate gave the engineer a clear signal.

A system of automatic signals was installed on the C., M. & St. P. Ry. early in 1902 by the Rowell-Potter Safety Stop Co., and operated experimentally for about six months. This system differed from all other automatic systems in that a safety stop at each signal and on 180 ft. in advance of each was added as an additional precaution. The method of obtaining power for the operation of signals and stops was a departure from all other methods and a very ingenious one. A track treadle or lever operated by passing trains wound up a set of springs in a machine which stored the energy thus obtained and converted it into motion of a pipe line to which were attached the signal and the two safety stops. The normal position of this signal was clear and with the first stop lowered and the second stop raised—when signal changed to stop position the first stop was raised and the one in advance lowered thus protecting against a failure of the signal to assume the stop position. When passed in raised position either stop would operate an air valve placed on tender making an emergency application of the brakes. The principal objection to this system was the small amount of storage capacity in the spring.

Another new system of automatic block signaling which has within the last two years been brought to the attention of signal engineers is the Miller electric cab signal. This system was exploited some years ago and was given up on account of several inherent defects, but the system has been redesigned throughout and arranged so that a failure of the apparatus gives the engineer a danger signal. An installation has just been completed through the Park Avenue Tunnel on the N. Y. C. in New York City, where it is used as an adjunct to the manual controlled block system. About 30 miles of double track are equipped with the Miller Sys-

tem on the C. & E. I., but it is not in use as a block system to govern trains, five engines only being equipped. The feature of this system is the absence of fixed signals of all kinds which materially reduced the cost of installation.

Several mechanical block systems have been devised, the two principal ones being the Rowell-Potter and the Black, both of which are at present in operation on elevated roads. The pressure of wheels of a train on an inclined bar furnishes the power for operation in both of these systems. On account of the number of working parts exposed probably none of the mechanical systems will ever be used on surface roads.

I. S. C. ENGINEERING ALUMNI

Mr. S. H. Hedges, '86, who was for several years connected with the Chicago Bridge & Iron Works is now President of the Puget Sound Bridge & Dredging Company with headquarters at Seattle, Wash.

Mr. F. R. Muhs, '92, superintendent of the Pacific Coast Branch of the American Bridge Company, has recently been visiting his relatives in Iowa while on the way between his headquarters at San Francisco and the annual meeting of the superintendents of the American Bridge Company at Chicago. Mr. and Mrs. Muhs have been sharing their home with a little son for the past eight months.

Mr. W. B. Craig, '94, is draughtsman at the U. S. Arsenal, Rock Island. His special work is in connection with pressed steel construction.

Mr. A. M. Price, '94, is a consulting engineer at Elgin, Ill.

Mr. J. T. Young, '94, is located at Hydro, Okla.

Mr. C. R. Cave, '95, is at Dyersville, Iowa.

Mr. W. J. Eck, '95, is assistant engineer, Signal Department, Chicago & Northwestern Ry. Co.

Mr. A. H. Foster, '95, is an electrical contractor at Red Wing, Minn.

Mr. G. G. Dana, '97, is chief draughtsman for the J. I. Case Threshing Machine Co., at Racine, Wis.

Mr. G. D. Heald, '97, is cable engineer for the American Bell Telephone Co., at Philadelphia.

Mr. E. R. Townsend, '97, is an insurance engineer with headquarters in Chicago.

Mr. C. J. Bristol, '98, is with the Globe Machinery & Supply Co., Des Moines.

Mr. James Galloway, '98, is electrical engineer for the Dupont Powder Co., Mooar, Iowa.

Mr. M. J. Pos, '98, is chief draughtsman for the Illinois Steel Co., South Chicago.

Mr. H. W. Skinner, '98, is factory engineer for Simonds Mfg. Co., Chicago.

Mr. J. H. Wykoff, '98, has recently accepted a position with the Tidewater Railway Company of Virginia. Since his graduation Mr. Wykoff has been connected with the Chicago Great Western Railway and for the past year has been holding the position of Roadmaster, with headquarters at Dubuque, Iowa.

Mr. G. D. Nicoll, '99, is mechanical and electrical engineer for the Indianapolis and Cincinnati Traction Co. This company has already in service lines from Indianapolis to Rushville and to Shelbyville, the former being a single phase installation.

Mr. J. C. Lathrop, '01, who is in charge of the Structural Designing Department of the New York Edison Company, has recently remembered his Alma Mater in a very nice way by writing for a couple of men to fill positions in his department. This is not the first time he has done this.

Mr. L. R. Muhs, '02, who has been connected with the New York branch of the American Bridge Company, has been transferred to the Pencoyd branch of that same company. He expects to spend about six months there and another six months with the Edgmoor branch, gaining some special experience, and then return to the New York branch and enter the contracting department.

Mr. H. J. Brunneir, '04, has a position in the Engineering Department of the New York Edison Company, New York City. Mr. Brunneir was married October 1st, and is now pleasantly located at 67 W. 107th St.

Four members of the Civil Engineering class of '05 are representing Iowa State College on the Panama Canal: Messrs. R. W. Clyde, D. B. Fegles, G. C. Peterson and T. J. Patton. They report being pleased with the work and none, as yet, have suffered at all from the effects of the climate.

Mr. C. C. Morris, '05, is now located with the City Engineer of Manila, Philippine Islands, having left the States last August.

Mr. A. R. Boudinot, '05, has severed his connection with the Clinton Bridge Company to accept a position with the Chicago Bridge and Iron Works of Chicago.

Mr. J. A. Buell, '05, has been with the E. J. and E. Railway, with headquarters at Joliet, Ill., since his graduation last June.

IMPROVED DRAUGHTING TABLES

The half-tone shows a draughting room in Engineering Hall, Iowa State College, equipped with a special design of table. Each table is a unit providing working space for four students at one time. Each student has an inclined adjustable frame in which his individual board can be quickly adjusted and over which slides a parallel ruler, replacing the T-square. The boards are 21x28 inches and interchangeable in all tables. The boards of absent students may be racked between the frames at center as shown.

Each unit is divided by a cabinet of small drawers, six on each side, furnishing locker accommodations for the instruments, etc., of twelve students of whom four may work at one time.

Each drawer is secured by a padlock furnished by the student.

Fifty of these equipments are in use by the Department of Mechanical Engineering and are very satisfactory. In their present form they are adapted to standard sheets 19 x 24.

Larger drawings are made on large boards laid on top of the frames and the T-square is used. A few boards of large size are kept on hand for special work.

The unit was designed by Prof. W. H. Meeker and the entire equipment was built in the college shops at an expense of $50.00 per unit. The floor space required for each unit is 6 ft. 9 in. x 5 ft.

SOME SHOP SYSTEMS IN IOWA

By J. W. HOOK AND G. P. LABBERTON

Although Iowa is generally spoken of as an agricultural state, her development along manufacturing lines has lately made great strides to the front. According to the last census report, she has made an increase of over one hundred per cent along these lines in the last ten years. This fact leads us to predict a bright future for Iowa manufacturing industries, and arouses in the methods that are used by Iowa manufactures today to arrive at the cost of their production, and the manner most universally employed in paying their employees. It is a known fact among manufacturers that in order to withstand the fierce competition which exists a system of determining the cost of their production, and the best method of compensating for labor, must be employed in their shops before the lowest allowable selling price can be ascertained. Some manufacturers, in order to eliminate the cost of maintaining such a system, use the selling prices of their competitors as a guide to their own. This method often proves disastrous, for different conditions, different management, etc., are very liable to have their effect upon the cost of production. The simplest and safest method is for each manufacturer to have a distinct system of his own.

For the purpose of gathering information, a circular letter, shown in full in the following, was mailed to the larger manufacturing concerns of the state:

"Dear Sirs:—

We are interested in the systems employed by shop managers in Iowa. We desire to obtain some data upon this subject from prominent shops in the state, and respectfully ask that you answer the following questions:

1. Do you employ the wage system of paying your men, that is, do you pay your men a fixed amount per hour or per day?

2. Do you employ the piece work system, that is, do you pay your men by the amount of work they do, regardless of the time it takes them to do it?

Enclosed you will find an addressed envelope in which you will enclose the answer to the above questions, which will be considered confidential.

Trusting that we will receive an early reply, we are,

Very truly yours."

One hundred and sixty of these inquiries were mailed and in less than a week one hundred and forty replies were received. The nature of these replies proved that the factory managers were greatly interested in the subject. It was learned by these replies that the wage system is mostly used by shops in this state. Of the one hundred and forty replies received only ten per cent make an exclusive use of piece work, only twenty per cent a combination of the wage and piece system, while seventy per cent employ the wage system throughout. The enterprises which make an exclusive use of the piece work plan are those which manufacture, practically, one line of goods. Clothing, shoe and glove factories, and in some cases carriage factories are examples of enterprises using such a system. Again there are factories which find it necessary to use both the wage and piece work methods of paying for their labor. In brick and tile factories, stone companies and also machine repairing shops where the work in some departments is very variable, it is found almost impossible to employ a strict and entire system of piece work. The wage system can be used in any factory and is generally the method used in small concerns, not because of its efficiency, but mainly on account of the great variation in the class of work that is required to be performed. There seems to be a great desire among most managers of wage shops to adopt a piece work system, but it is difficult for them to find enough of one class of work upon which to determine a fair rate.

The inefficiency of the wage system lies mainly in the fact that it does not reward the laborer on merits of the amount and quality of the work performed. There are hardly ever two men alike, nevertheless, both often receive the standard wage. There is no incentive for the workmen to do more than is necessary to enable them to hold their job, for he would not profit by any extra exertion, and for the same reason does he fail to improve his present methods. This failing to bring out a man's best effort is a direct loss for both employer and employee and is charged up against the wage system.

To eliminate some of the unsatisfactory conditions often existing in the plain wage plan an accurate cost keeping system is sometimes introduced. In this system, close track is kept upon the men and they are paid a wage according to the work they are each capable of doing. In Iowa it is found that nearly all

wage shops of any note employ such a system. An illustration of a wage cost keeping system such as is most commonly used is here given.

A certain company manufactures doors, cabinets, show-cases, etc. The company employs about seventy-five men who are paid by the hour. All office help is paid for by the month or year. The secretary of the company states that the two fundamental reasons for using a cost keeping system in his business are, first: to take care of the fluctuations in prices of material, insurance, labor and taxes, and second, to keep track of his men.

In this factory every thing goes by number. The men are numbered, and everything is referred to by number instead of by name or description. When a job is contracted it is given a number which it bears throughout the process of manufacture. When the material for a job of a certain number is ordered it is specified that it be shipped under that certain number. This is done so that it will be easy to determine for what order a certain shipment of material is for. When the bill of material is re-

COST SHEET

	NAME	A		B	C	D	E	A^1	B^1	C^1	D^1	E^1
		No. 1	No. 2									
A	1 cabinet	2.60	1.75									
B		1.30	.25									
C		4.00	2.25									
D												
E												
Prod. Labor								12.15				
Non-Prod. Labor 20 per cent								2.43				
Sundries 30 per cent								3.64				
Total								18.22				
Contract Price								21.00				
Net Profit								2.78				

ceived and the job is ready to be worked, the clerk in the office enters the name and number of the job down in the cost keeping books, a page of which is shown in the accompanying blue print. Assume the job to be a cabinet. This work is entered if it happens to be the first job to be entered upon this sheet, in the horizontal symbolized by A. If the job be the second job to be entered upon the page the name will go in the horizontal column symbolized by B. And so on. Assume that the number given the cabinet is 1. This is also entered in the same column with the name of the piece. Then as the work progresses the vertical column A is filled out from the time slips that are handed in by the workmen. Sometimes two or three men are set to work upon a job. No. 1 and 2 in this case. The number of workmen is noted in the vertical columns under A, and directly underneath, the amount they earned upon the job. When the cabinet is finished, the productive labor cost is added up from colum A, and carried over to another column A' as shown. Then a percentage is taken of this amount to cover the non-productive labor cost, and added to the total productive labor cost. Then of this total another per cent is taken to cover shop maintenance, taxes, insurance and sundry expenses, and this added to the last total. This total gives the cost of the article. In a line just below this is entered the contract price, the difference between this price and the actual cost being the net profit or loss. Below this is left a large space for remarks.

The percentages above referred to change from year to year, and are arrived at practically from the experience of the year before. It is evident that the material cost is known. The yearly expense incurred by the non-productive laborers is also known, it being determined by the wages paid out. The repairing expense is known by the money expended upon repairs for the establishment. The tax and insurance, and the general depreciation of factory and equipment is not so easily determined. The two former items, the taxes and insurance, are available from the year previous, and stand as a basis for determining the percentage for the present year. The depreciation per cent is found mostly by a judgment inventory, the ability of the man who takes the inventory to judge how much less a building or machine is worth after a year's use, being a large factor in its correct determination. Experience, also, has something to do with this determination, the life of a machine or a building of certain structure and the change from year to year, being a strong factor in its derivation.

So extended has been the experience of this firm that they can almost ascertain the cost of their orders before they are made. They have from experience almost exactly determined

what it will cost to manufacture any article of their production. If a man is given an amount of work to do, and he does it in less time than it has ever been done before, his wages are increased accordingly, while on the other hand if it requires a longer time for him to perform the labor necessary to finish the job, his wages are decreased and he has no grounds upon which to feel hurt or imposed upon.

The manner of keeping track of the labor is by small cards, which are given the workmen when they begin work. Upon these cards are left spaces for the name, date and article to be manufactured, also the number of the job and the number of the workman. When a man works a certain time upon a job, he notes down his time. From these cards his time is transferred to the cost keeping books, a page of which was previously described.

The secretary claims that his system works well and that he experiences little or no trouble with it. The men are really given something for which to work, for if they finish an order in less time than is required, their wages are increased correspondingly.

The piece work system is also an attempt to remedy the unsatisfactory conditions existing in the wage system, and it has proven a success in most cases where it has been judiciously applied. In some cases, however, this system has developed to be nothing more than a method to extract more work for less pay from the workmen. In such cases, the system has no incentive, since the men know that the piece rate will be reduced as soon as a high speed with a corresponding high pay is secured.

An efficient modification of the piece work system is employed by a carriage company. The nature of the work here is such that the system employed works to good advantage. The company owns the factory and machinery, and furnish the material, but the work is all under a contract. That is, a man contracts to do a certain job of work at a certain rate for a specified time. The system as used is described as follows:

First, the factory is divided into four general departments, namely; blacksmithing and wood working, paint shop, trimming department where tops, cushions and backs are made, and the shipping department where all goods are set up, inspected, crated and shipped out.

A man is hired to do a certain operation. For instance he signs a contract to cut all leather and cloth for backs and cushions. He hires to be paid according to a rate agreed upon by himself and the manager. This workman is responsible for the cutting of all cushions and backs, and if at any time he finds that he cannot supply the demand he must procure help at his own

expense. Another workman hires to sew all of these leather cuts and lining cuts together. Also another workman contracts to fit all of these backs and cushions to the carriage. These three form the trimming department, and one of the laborers in this, which are three in number, is selected by the manager to act as foreman. The duty of the foreman is to see that the work is all done well and that no defective material is used. He also sees that the operations done by each man are correctly counted. The same method of operation exists in other departments.

TIME SHEET Week Ending............Department...........

O. K'd by................, Foreman..... No.......Name...............

Be sure to enter date, price, and figure both piece work and day work separately each day.

Mo. Day	How many	DESCRIPTION OF WORK DONE	Price	Totals	

FORWARD

The accompanying blue print explains better the way the actual wages of an employee is registered. At the extreme left hand, the date is entered. Following this column is a place for registering the number of pieces made, price per hundred and finally the total amount for the number made. At the top of the sheet are blanks for noting the end of the week to which one blank refers, the name of the foreman and the name of the workman. These sheets are turned into the office weekly, where they are entered upon the pay-roll.

A most interesting feature of this department is the cost sheet. The manager lets the workman set the piece prices. For instance to make it plain the manager takes the matter up in the trimming department for the season of 1906 about October 1st, 1905, at which time the prices for the different operations are agreed upon by the manager of the firm and the workmen in that department. The same method is utilized throughout the entire factory. When the price is agreed upon the company has a later or extra agreement that if the price of one of the operations is so low that a piece worker cannot make a certain amount in an average day's work, that the price for that operation be taken up and reconsidered. The company on the other hand binds itself not to ask for a readjustment of prices during the season even though some of the prices prove to be very high. The cost sheets above referred to were very intricate indeed. It was even noted what the cost was of boring a single hole in some por-

tion of the carriage. The items entered upon the cost sheets numbered far up into the hundreds. While explaining these sheets to the writer the manager said, "We must know to within a few cents of what one of our carriages costs us. If we did not we would have been run out of business by competition long ago. Why it was only last week that I sold buggies at a dollar profit." This statement shows the importance of cost keeping systems in factories.

The depreciation cost, also the non-productive labor and sundry expenses in this factory are arrived at in a manner similar to that of the company previously described.

Probably the best instance of piece work in the state is employed by a certain firm manufacturing but one article, this fact making it possible to use the piece work system in a very efficient manner.

The company issues a separate card for every operation including cards also for stock to be delivered from the warehouse to the shop, same being covered by cards marked, "Spoke Steel," "Hub Room," "Box Room," and "Tire Room." Taking up one of the cards, for instance, the one marked "Spoke Steel," it will be noted that spaces are left at the top of the card for the general description of the wheel. The vertical columns immediately below this description supply places for keeping the date, the pounds of steel issued out by the ware-keeper, the amount of good material returned to the ware keeper, the number of pounds of material returned including the waste, the waste and lastly the name. At the bottom of the cards are places for the signature of the foreman. The other three cards of the ware department describe themselves, they being essentially the same as the one just described. The general description of the wheel occupies the top of the card, while the labor and inspection of material is registered in the vertical columns below.

The original order is entered upon the large white card designated by Form 1 2m 9-6-98. This card does not go to the shop. It is issued by the sales department to the shop office where all time and wages are kept. The timekeeper holds this card in the office until shipment is ready to be applied upon same, but in the meantime he issues shop cards as illustrated by forms 7, 8, 9, 10, 11, 15, 15a, 18 and 19. These cards are taken into the shop by the foreman and put into effect when desired under the direction of the shop superintendent, who has access to all cards. The shop or piece work cards designated by the above form numbers are retained in the shop by each operator until the order is completed unless for some reason, such as cancellation, or transfer of the piece worker to some other order. The work done each day as reported upon these piece work cards at the

SPOKE STEEL ORDER CARD

Date............Order............Lbs.............Size ....

Dia.................Size of Tire....................Hub...............

Date	Lbs.	Returned from shop	Returned Lbs.	Waste Length	NAME

Form 21
2M 1-4-05 ....Foreman

HUB ROOM ORDER CARD

Date ....Order..............Hub..............Dia...............

Drilled.....................Oil Hole...................Axle...............

Date	No.	Spoiled	Defective	Returned from shop	NAME

Form 20
2M 1 1 04 ....Foreman

different machines is taken off by the time keeping assistant every morning when he goes the rounds to get the records of the previous day. The actual cost is taken direct from the cards above mentioned. If a rush order is desired, the shop foreman is advised of the fact and sees to it that the men have the proper card with which to work upon the rush order in question. The fact that the order is to be rushed is not indicated upon the cards themselves, but upon the large white card which is a guide to the superintendent and his foremen, and is always at hand in the shop office, as well as convenient for the sales department when making note of any changes in the order or demands for extra rush. The different colors of the piece work cards simply serve as a handy method of keeping each operation separate from the others, although the name upon the card is issued for that purpose also.

SHOP ORDER NO.........

Ship via ....190..

Order of ....

Dated ....

No. Ordered	Description	
....	Dia. of Wheel	No. of Spokes ....
No. Shipped	Size of Tire	Size of Spokes ....
	No. of Hub	Size of Hub ....
....	No. of Box	Size of Box ....

Remarks:	Entered ....190..
....	Will Ship ....190..
....	Shipped ....190..
....	Weight of Wheel ....

Form 1. 2M—9-6-98

The vertical columns upon the piece work cards are similar on each card. The difference in the operations on the different machines makes the description at the top of each card unsimilar. Also some of the cards give the price of the operation per one hundred while some others give the price per one thousand. All cards are signed by the foreman in charge of the department under which the operation is performed. Each card is provided with a column for day work. This column is used upon orders which are so small that it does not pay to run it through on the piece work plan. These cards are called for by the foreman when he is ready to make up a certain order and every operation in the shop at the end of the day filled in with the necessary data which is taken off by the time keeping department the following morning, and entered upon the proper books in the time keeper's office. From these books a complete record is kept, and what is being done, not only on the cards themselves, but also in the cost books which are transferred from same, can be determined at any time. It is evident from this that stock and labor inventories can be taken from the books at any time without closing down the shop.

In regard to the cost keeping system employed by this company, it would be well to quote from a letter received from the secretary and manager of the firm to whom we are indebted for valuable information.

"As to methods of cost keeping, will say that these vary greatly with different shops or lines of work. With us it is a more simple matter than with some others, on account of the fact that we make one line of goods only. For that reason

what would apply in our business would not do for any other only in a general way. Although we could figure the exact cost of each individual article, we do not do so, on account of the fact that all of our products are so similar that we estimate the cost at so much per pound, which we get at the end of every month covering the month's run by assembling all of our cost accounts together and dividing it by our total tonnage output for that month. Of course, on some expensive articles out of the usual run, we figure special costs according to the particular construction, but this does not apply to the bulk of our output which consists of the regular average construction."

The cost and labor paying system of another important factory is an elaborate one and the methods employed are not those which are ordinarily employed in a job shop. In the foundry when a moulder is given a job of work, he is notified as to how many castings are wanted from the pattern and proceeds to go to work upon same. After the day's moulding is finished and just previous to pouring the metal, the timekeeper counts the number of flasks which have been made by each particular moulder. This record is then taken and entered upon a weight sheet and sent to the cleaning room. When the castings have been cleaned away on the following day, the difference between the good ones produced and the total number made by the moulder shows the loss, and the employee is only paid for the work which comes out perfect.

A somewhat different system is employed in the machine shop. Here when a workman is given a job he is given a time card at the same time. This card shows the time of starting the job and also what the job is, also the operations which are to be performed upon the particular piece. When the job is completed the time of finishing is set down as is also the number of pieces machined. In this way the firm not only pays for the work which is performed, but they have a check upon it by being able to ascertain the exact number of hours employed, and can figure these at the usual day rate to see if the piece work prices are too high or too low. It might be said in connection with this that the firm does not take each casting and pay so much per piece for it complete, but that a piece work price is established upon each operation.

The stoneware industry of this state employs a system of piece work in its shops. In one shop each man does a certain kind of work. One man is given as many moulds as he can fill each day, which he counts himself and which are tabulated, checked and approved by the superintendent daily and turned into the office for book tabulation, each man having a page of his own with a carbon copy every two weeks pay day.

Every day's work is a comparison against the previous day, the result being a larger output, while the employees make from twenty to thirty per cent more wages than if they work by the day.

Perfection in manufacture is insisted upon, or the goods do not count. The raw clay is mined and prepared for the makers of stoneware by the ton, the kilns are set and drawn for so many hours each, according to the capacity of the kiln. The same method is used in drawing the stoneware out after it is burned.

The man who does the glazing is paid so much per one thousand gallons. That is, he must keep track of the capacity of the vessel that he glazes. This serves as a check against the amount manufactured which prevents any possible chance for an employee in the moulding department to "stuff" the report.

Factory hands are not permitted to work more than ten hours per day unless in extreme cases.

The shoe factory has, probably, as many complications with which to deal as any other enterprise in the state. To make such an enterprise a success in this state, successful enough to compete with the large factories in the east, requires the keenest ingenuity on the part of the manager. Nevertheless, this state has at least one successful shoe factory.

The factory is a large three story and basement brick building, well lighted, and occupying an accessible position in the city. The building faces the south with an office on the first floor at the extreme southern end. The basement is used mainly for a storage room, although there is provided in this portion, machinery and appliances for staving the soles and cutting and pressing the heels. The laborers in this room are mostly men with a few girls who perform some of the lighter labor. In

Form 3 REQUISITION SLIP—DEBIT TO EACH ROOM

Date .... Storekeeper deliver to ....

Order No. .... Foreman ....

the store room the man in charge is responsible for every item of material that is stored therein. When the material is stored away in here he signs for it, and if through his neglect any of it disappears, he is responsible. This man who is called the stock keeper is authorized not to issue out even as small a thing as a package of nails unless he is ordered to do so by one of just authority. When an order is ready to be made up, the foremen of the different departments fill out Form 3 and sign it and send it to the stock keeper. The stock keeper issues out this amount, and makes note of same which he sends to the office in his report. By looking over these reports in the office, the manager can at any time tell exactly the amount of material there is on hand. As will be noticed upon the accompanying Form 3 there is a blank left at the bottom for registering the Order No. From the data filled in here the manager can determine the amount of material any finished order required. This knowledge is a large factor in the determination of prices of incoming orders.

Upon the third floor of this building is located the cutting and stitching room. In the cutting room the order is begun to be made up. A small storeroom where all upper stuffs and linings are stored is located in the rear end of this room. The foreman in charge of this department issues out an amount of goods for the different orders and fills out Form 69 which is merely a blank for recording the material allowed, used and returned. The term Case No. refers to number given the order when it comes to the factory, and the number it retains throughout the process of manufacture. The term Sample number refers to the description of the shoe, from which the order in question is to be made. That is each sample shoe is given a special number.

Form 69 Assorter

Date Cutter

Stock Price

Topping Price

Case No.	Pr.	Sample No.	DESCRIPTION	All'w'd	Issued	Ret'n'd	Top All'w'd	Top Used	Gain	Loss

The employees in this room are men and boys, and each one keeps track of the number of outsides, linings, trimmings, tongues and tips he cuts for which he is compensated by the hundred. Form 44 is the slip each workman fills out and deposits after each period of labor in a place easily accessible to the office. This slip is called the workmen's slip and is used by all of the workmen in the factory. Each workman is required to fill out and extend these slips at the time he does the work. When the checker in the office goes over these slips he compares them with the record card, then with the piece price for that particular work. These piece prices are kept upon small record cards in a small filing case near at hand in the office. In this room the patterns which are made of metal are located upon shelves which are numbered. By index these patterns can be located.

Form 44. NOTICE

All shoes damaged in any manner will be charged to the workman whose fault it is. Parts of shoes damaged in process and the expense of putting in new parts will be charged to the workman damaging same. Workmen allowing damaged work to pass by without notifying the foreman in charge, are liable to discharge.

A B C SHOE CO.

Name..

Date.............................. No..................

Occupation ....

No. Set	Pairs	Kinds	Price	Amount

As the uppers are cut they are transferred to the stitching room which adjoins the cutting room upon the north. This room is larger than the cutting room, and is fitted with all of the machinery that is necessary to assemble the upper of a shoe. The machines in this room being small are located upon a continuous table on either side of the room, the power being furnished by a countershaft that operates underneath. The machines are set

so that the work on a shoe can progress right down along the table. That is to say, a shoe begins at one end of the room and goes through to the other without having to be brought back for a single operation. The employees in this room are all girls who are paid by the piece. Form 44 is used in this room as it is in the others for turning into the office the amount of work done by each employee. The rapidity with which the work is turned out in this department is indeed remarkable. Each laborer has become so accustomed to her line of work that she can turn out her portion of the work with little effort at a rapid pace. The machines mostly consist of sewing and stitching machines, although there are devices for making buttonholes, sewing on the buttons, putting in the eyes and eyelets and for shaving off the leather so that it will be thin enough around the joints and seams to look well in the finished product. The piece prices for the operations in this room are recorded upon a record card upon which is placed for general description of the work in question to the date. No., pair, general description, sample number and case number. It has besides this a full description of the shoe and work in detail and in the order it is performed. The checking is done by placing the price and total in their respective columns and in another column "Ck" the number by which the operator goes, and the date the work was performed is placed immediately under. As the operations are in rotation on the card, it is to be seen that the last operation recorded will show the location of that particular lot in the

Form 75

Date ....

Case No. ....

Case No.	No. Pair	Received in Stitching Room	Left Stitching Room

works with the date the last operation was performed. These record cards are held in open, shallow cases with sloping ends, shallow enough so that about one-fourth of the card projects above the case. The case is made sloping so that the checker can check the cards without taking them out. They are placed in the case in numerical order, each lot of shoes being given a separate number. When the work enters the stitching room the fact is noted upon Form 75 which merely has reference to keeping track of the work. This card has columns for recording the case number, the number of pairs and finally the date when the lot leaves the room entirely.

From the stitching room the shoe, or better say the lot of shoes goes to the second floor which is the bottoming room. The general name of a shoe is derived from the manner in which the bottom is attached. In the bottoming room the soles and heels are attached and the shoe finished ready for the ironing and polishing process on the floor beneath. The machines in the bottoming room are arranged, as in the stitching room, in the order that the manufacture of the shoe requires, and are operated by men. The labor in this room is compensated for by the same method as above described, Forms 44 and 36 being used as in other departments. Another form is used in the bottoming room which is known as the bottoming room record blank to keep track of the work.

READY FOR SHIPMENT

------------------------------190..

Lot No.................. for..............................

is now ready for shipment.

....

Shipping Clerk

Approved ....

Form 66

From the bottoming department the lot of shoes goes to the ironing and polishing department on the first floor. Here the shoes are polished and crated ready for shipment. When a lot of shoes are ready for shipment the shipping clerk fills Form 66 and sends it to the office where it is approved by the man-

ager. If this form is approved the customer is notified and the lot shipped.

Stock No.................. Width.................. Size..................

No. Pair Received	Dr.	Bal.	Cr.	No. Pair Sold

Form 76

The store room is also located upon the first floor. For keeping track of this storage Form 76 is used. This blank furnishes places at the top for recording the stock number, width and size. At the extreme left hand are crossed columns for tallying the number received. At the right hand side similar columns are located for recording the number of pairs sold. In the center of the card are located columns headed "Dr.," "Bal.," and "Cr." By inserting in the "Dr." and "Cr." columns the number of shoes of the style specified by the stock number that are going out and that are coming in a balance of the number of shoes of that particular stock is determined. Thus if a customer comes to the factory and wants a certain style of shoe, the man in the office can by looking over Form 76 determine whether or not such a shoe is in the store room.

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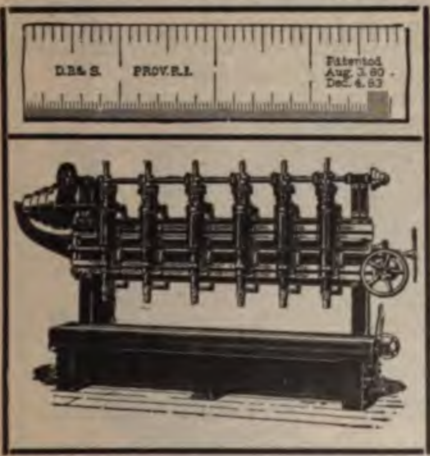

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THE IOWA ENGINEER

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PROCEEDINGS OF THE SECOND ANNUAL CONVENTION OF THE IOWA ASSOCIATION OF CEMENT USERS

The Second Annual meeting of the Association was held at Ames, February 8 and 9, 1906. The attendance was up to that of last year when the Association was organized. The high character of last year's program was even surpassed in the papers presented and the enthusiasm displayed, which is but an index of the rapidly growing interest and wonderful expansion in the cement industry during 1905. A fair proportion of those in attendance came from neighboring states. The meetings were held in the large Assembly Room in Engineering Hall at the Iowa State College.

The exhibits of cements, of cement products and machinery were also a prominent feature of the convention. The cement exhibits were placed in Engineering Hall and machinery in the Athletic Training Quarters located immediately to the west of this building. Nineteen different firms engaged exhibit space including three of the leading cement manufacturers.

The Cement Users Associations of the country have become an important and almost essential factor in the development of the industry which they represent. Those who use cement in any of its numerous applications are rightfully coming to depend upon these annual gatherings as necessary to their advancement. To the uninitiated the manufacture of cement products may appear so simple as to require little skill or knowledge for success. It is

just this that leads into the business many entirely unqualified persons who, after placing an inferior product on the market, finally realize their deficiencies. First class products, and none other should be sold, require *skill in manipulation* and above all a *technical knowledge* of the *properties of cements* and the various aggregates. It is felt that this word of warning is not out of place for it certainly has an important bearing on the reputation of products which bid fair to be the chief structural materials of the future.

In the dissemination of technical information and the results of practical tests and experiences the Associations serve their most important function, for in no other industry is such more needed. The bringing together of members of the craft for the mutual interchange of opinion and the discussion of topics pertinent to the business, is another important purpose of the Convention. In all these particulars it is the effort of the Iowa Association to keep pace and even lead among the state and national organizations devoted to these same interests.

Recognizing the widespread and increasing importance of the cement industry and the necessity for specific instruction and knowledge in all of the silicate industries including clay and glass as well, resolutions were passed by the Association urging the establishment by the present legislature of a school of Ceramics in the Iowa State College. A committee was appointed by the president to present this matter to the legislature. The universal demand that exists for such a school certainly justifies the hope that our law makers will see fit to consider favorably these resolutions.

We were fortunate this year in being privileged to listen to some of the leading authorities of the country in matters pertaining to cement and its uses. This is the sort of instruction that Iowa cement people need and welcome, especially in view of the fact that our state is one of the principal users and a prospective manufacturer of cement.

The first session was called to order by President Coutts at 2 p. m., Thursday, February 8.

President Coutts—It is scarcely necessary for me to say that it gives me great pleasure to meet the cement users of Iowa in this, our second annual convention. I am very glad to see so many men interested in this great industry in which we take so much pride. Now, I have simply one request to make and that is that every member of this Association will just forget that there is anybody else around; feel perfectly free and at home and that you are the only one here. It is a sort of shrinking that humanity seems to be heir to that hinders us a great many times and we nearly always see it crop out in a meeting like this. Now just

let us put that aside and go right in for a splendid profitable meeting. There is more in this subject than we could learn if we were to stay here for the next hundred years but there is a little that we can learn by being here today and tomorrow and we will make the very best of the time at our disposal. A more formal opening of this convention will be made at this evening's session. The parties who were expected to be here are unable to be present this afternoon but will come this evening and you will receive greetings from the representatives of Ames and of this institution tonight.

REMARKS BY MR. GEO. H. CARLON ON SUCCESSFUL BLOCK MAKING.

I have investigated quite a good many block plants during the past year in Iowa and other states. I have visited and inspected quite a number of cement buildings also. I find that there is hardly one of the plants today that is making a block that is really fit to go into a building nor have I found one building erected of cement blocks that would pass mechanical inspection. This ought not to be. I do not think there is any better material in the world for building purposes than cement when properly used. We have sixty-four block machines patented in this country and a great many used that are not patented. I think you will agree with me when I say that not one-fourth of these machines is fit to make a block on. They are intended to sell to make money on. I am not saying anything against the block machine men. There are quite a number of lumber merchants that have block machines; there are also doctors and lawyers in the cement block business that know absolutely nothing about it. That is where the failures come. I know of one lumber merchant who paid about $200 for a machine, manufactured about 100 blocks and went out of business—never manufactured any more blocks. His blocks were worthless. A man came into our factory this winter and told me he was going west to Colorado and wanted to start a cement block factory. He said he never had seen cement blocks made but wanted to know how it was done. He stayed in our factory about thirty minutes and learned the whole business. Now, is it any wonder that he made a failure of the cement business! I once heard of a minister that wanted to build a church. It may be all right but suppose some of you block men should try to preach in his church. I believe that most of us could preach about as good a sermon as this preacher could make blocks.

Mr. C. W. Stevens—I heard some remarks about the proportion of cement to sand—1 to 4 or 5. Why should a block-maker use any more cement than is used in concrete for railroad bridges where 1-7 part by measure of cement is the proportion? That is the proportion we use in making blocks.

Mr. J. W. Dickinson—I think the answer to that question

is that they use very coarse aggregates in connection with the fine materials. You can take any mixture of 1 to 4 or 5 where your aggregates are relatively small and then put in 2, 3 or 5 and up to 8 parts of coarse rock, possibly some pieces 6" and 8" through. You have not weakened your mortar or concrete a particle but you are able to have a total mix of 1 to 12. I think many in this room have seen perfectly solid concrete 1 to 12. I have seen better concrete mixed 1 to 12 where the aggregates were proper than I have 1 to 6 where the aggregates were improper.

Mr. D. P. Faus—I can only say that I have done a great deal of work under railroad specifications and they are very particular to have the proper aggregates. The common specification is about 1 of cement, 2½ of sand and from 5 to 7 of crushed stone which, when united in solid concrete is equal to about a 1 to 7 mixture. The cement and sand fill the open space in the rock, so that it doesn't make as weak a mixture as it is really represented to be. When you get the whole body mixed together you will really have just a bare margin over the amount of coarse aggregates you are using and 1 to 3 of this mixture is equal to about 1 to 6½ if the aggregates are taken already mixed as they come from a gravel bed.

Speaker's Name Unknown—In regard to concrete much depends on what its exact use is to be. If it is for massive work as in railroad construction you can use less cement and larger aggregates than you could for smaller work. I may say further as a general statement that I am most happy to be here and to hear such common sense and plain talk. I think much good will be derived from this convention. The cement block business is to be one of the greatest industries in our country. Today it is almost at a standstill in various sections due entirely to the failures. There are machine men who are selling block machines to persons that are utterly incompetent to manufacture a block. You will find any number of cement block plants for sale in Illinois where good men have gone into the business and then out of it. The cement block has been a failure simply because the people are incompetent. What we want to do at this convention is to bear right down and bear hard and see if we cannot bring action to restrict the sale of machines to men only who are competent to operate them and to make a good block; so that the concrete business can stand on its own merits.

To return to the concrete question: You go almost anywhere, even in this town, and you see poor sidewalk work. There are men however who are building a good block and the city authorities should take hold of it, put those blocks to a test and make them come up to a standard, and put out those men who are in the busi-

ness solely for gain and have no honor or honesty behind them. This is a broad subject and all men here who are interested and know something about cement will appreciate that a person cannot touch all its phases, but I want to start the discussion so that you will not go back home and do as the man at Milwaukee did. He made a block with a 1 to 9 mixture. I condemned his block and proved it no good. You hear many men talk about 1 to 12 for a sidewalk. A 1 to 12 concrete proposition is of no earthly value. They will tell you they are putting in a 1 to 6 or 8 or 9; why do their blocks crack? Because they have not enough cement.

Speaker's Name Unknown—The old English system, Mr Chairman, was to take the sand and cement, mix them in a box dry and then wet that up into a mortar so the cement was so thoroughly wet that it was "milked." I might use the term "the cement was precipitated in the water" if that will fit the idea any better. Then the other material was thrown in, in the proportion wanted, with the cement that is thoroughly "milked." The sand and the other smaller particles are thus all thoroughly coated, I might say, whitewashed, and then you have a bond.

FUTURE OF THE CEMENT BLOCK IN THE BUILDING TRADE.

J. B. SCHIFFERDAKER, *Waterloo, Iowa.*

In the following article on the manufacture and use of concrete blocks, I will endeavor to present my ideas in such a way that the mechanic with an ordinary education will be able to understand them. I do not intend this article to be of much value to the educated engineer, but it is for the use of the ordinary man who contemplates the manufacture of concrete blocks or other cement building material.

The manufacture of concrete blocks and artificial stone has been making progress and successfully competing with cut stone of ornamental character, both in price and quality. In hollow blocks there has been most unusual development. It has been so rapid and has appeared so attractive a field for investment that inexperienced persons with insufficient capital have rushed into the business to get rich quick, and the result has been poor products that have not been acceptable to the builder. And this has been no small drawback in the development of concrete products. The machine man contributes his mite in this direction by selling his machine to any one who has the money. Nevertheless, blocks and all artificial stone have come to stay and it will be a question of only a short time when first class materials will be uniformly produced that will be acceptable substitutes for brick and stone, and which will in cost compete with wood as building materials.

To make a success of the concrete block business those engaged in it should have a good knowledge of cement, a knowledge of architecture and designing and experience in using cement and concrete that will enable them to select and prepare the proper ingredients to make a perfect block. To begin with, we have a rapid progression [illegible] in what has been done the past three or four years by [illegible]. As indicated, the [illegible] large [illegible] the [illegible] people and it is a fact that a number of plants have closed their doors and wish to sell their machines at any price.

The first and most important consideration is a good reputable brand of cement. The color is a very important factor. I have used many good cements but with some very great care must be exercised in the amount of water to get a uniform color. If exactly the right amount is not used you will get blocks of many shades and colors. With one well known brand of cement I have found that the moisture cannot be gauged but it must be watched and the water applied to the minute in curing, or one block may be as dark as coal, another a shade lighter, or, there may be five or six shades of color. A stock of this kind is certainly not desirable. On the other hand, there are cements with which any amount of moisture may be used in mixing, and water applied today, tomorrow, or not at all, and the blocks will still be all of a color.

Next in importance is sand, gravel or stone. Whatever class of material is used it must be clean and sharp. The proportion of cement to be used will depend on the strength and appearance desired. So far as strength is concerned, very poor mixtures, say 1 to 7 or 8, may answer every requirement. I never make a block less than 1 to 5. Blocks made of such a poor mixture as 1 to 7 or 8 will absorb water like a sponge and will not answer for walls in a dwelling, although they may be very good for partitions, retaining walls, or buildings in which dampness is no objection. For dwellings, a mixture of less than 1 to 5 is not to be recommended. Much depends of course, on the character of the sand, gravel or screenings to be used. With properly graded gravel or screenings containing a large proportion of coarse material a 1 to [illegible] mixture will be found better than 1 to 2½ or 3, of cement and sand only. I would say that a 1 to 4 mixture, properly [illegible] and applied, will possess fair water-proofing qualities; [illegible] dwellings to be furred and lathed and plastered.

[illegible] the machines, there are a multitude of them and they [illegible] block. The quality of the block produced [illegible] makes it than on the machine. [illegible] needs, giving preference

to the most substantial in construction, and be careful that you get value in place of blue sky for your money.

As to the future, we will still use the machine, but will face our blocks with a mixture of 1 to 1½, and 1 to 2, of any desired color or shade, and this facing will be milled together to insure proper mixing and to get the fineness necessary for density and appearance. It is not necessary to say anything in regard to applying the facing as some of the machines make the block with the face up, some with it down, and the most of them with the face on one side. I use the latter. I fill the machine with both facing and concrete at the same time and have a divider in it to prevent using too much facing. When the machine is filled, it is well tamped with heavy tampers of iron not over one inch thick and three inches wide. There should be no fear of injuring the concrete by thorough tamping but get a machine that will not spread or spring. Placing the concrete and placing it well is half the battle and blocks of such make will stand in buildings many stories high when properly cured. Such blocks of 1 of cement to 4 of sand and gravel, one year old, will have a crushing pressure of 2,000 pounds to the square inch, calculating the full block 9x10x32. Such blocks would be very good to put in our largest and best buildings, but they should be protected with a facing made of ground marble dust, granite, or other class of material the owner may choose. There is no stone quarried that we cannot imitate if desired.

There is also another make of block that will follow our press brick very closely, and that is the paste or poured block, such as we make our ornamental work and trimmings of. Blocks of this kind are more easily made to imitate natural stone, even though they will not withstand the crushing pressure of well made tamped blocks, according to tests by German engineers. And we get sharper edges with less liability of marring them. This so-called wet system has been a little slow about coming to the front because it takes a better mechanic to use it. The blocks must be hand-pitched, which makes them a true imitation of quarried stone. It is my candid opinion that this class of blocks will be used for all our better construction, and the tamped block for factories, foundries, etc. All blocks and brick as now manufactured will be superseded by a superior article, manufactured in accordance with higher scientific methods.

There was a time when all brick manufactured were of a common kind, similar to the lowest grade $7.00 per M. of today, but with the advent of a demand for a better article improved machinery was introduced, and higher grades and higher prices made, brick running as high as $80.00 per M.

The concrete block of the present is undergoing the same

change that the common brick of the past has undergone. There has been one thing that has hindered more than others, and that is our inability to cure them fast enough. This will be overcome by using steam rooms for curing, something I have been considering for some time and which I think will prove satisfactory and practicable.

There are a few points that I wish to strongly emphasize.

Don't start in the manufacture of concrete blocks unless you understand the business or are willing to hire some one who does.

Don't think you can run your plant with nothing but cheap labor.

Don't use ice cold water to mix your concrete.

Don't make blocks in freezing atmosphere.

Don't make up more concrete or cement than can be used in half an hour.

Don't try to make clean sharp blocks with dirty or rusty moulds.

Don't try to trowel or work cement after it has acquired its initial set.

Don't disturb the block after it has commenced to set until it has completely hardened.

Don't use too much sand and gravel because it is cheap.

Don't try to make a cheap block to compete with frame construction for you cannot do it.

Don't make all the blocks with one face or mould.

Don't forget to keep your blocks wet four to six days after they are made.

And last but not least, make a good block and get a good price for it.

DISCUSSION.

Question—I would like to have the speaker explain the grades of cement used.

Mr. Dickinson—I would ask to have that answer not made. I would like to eliminate every bit of commercialism from this body. We are not here in a commercial spirit.

Mr. A. E. Metzgar—Mr. Chairman, I told a little incident at the beginning of our convention last year that has given me a disreputable name in the convention and I want to repeat it this year. Up at my home in Grundy County my wife uses one grade of flour and my neighbor uses another, and neither could make good bread with any other brand. I have eaten at my neighbor's and I call it pretty good eating at both places. In order to illustrate the matter I will tell the little story that I told you last year. The old Indian said if they were all like him they would

all want his squaw but the other Indian said if they were all like him no one would want her.

Mr. Schifferdaker—Mr. Chairman, I am not here to discuss the quality of cement, although in my experience I have used a great many brands. Neither will I discuss the cement question as to which brand should be used or anything of the kind if you come to me after the convention. That you must find out for yourself. If you come to my plant you can see the brands of cement I use and that would be the only way I would ever inform you.

Mr. O. U. Miracle—It occurs to me that a very happy solution of this matter would be to simply advise people who are buying cement to buy brands only which can be guaranteed to pass the tests and specifications required by the American Society for Testing Materials. These specifications have been adopted and widely discussed and I believe there is no one here who has a cement for sale that would not be willing to furnish an article that would meet them. A cement which will pass these specifications is absolutely safe.

Mr. Stevens—We have used a great many brands of cement. Blocks made from some of them if dried and then wet will become discolored, while if you keep them slightly moist, or in a damp place, the color will hold good. Others even if you do wet them will discolor. There is a great deal in the curing.

Mr. Schifferdaker—I must answer that question. I wish to have it understood that I do not mean any particular brand of cement. I say they are all good but in my experience I will say, and you may have the benefit of it, that the blocks made as they are at the present day are too dry, every one of them, for any purpose. Then if you are not awfully careful with some brands of cement you either make good color or discolor as I stated. I don't care if you apply water afterwards, it is the first application of water that does the business; or whether you have it in a shed or not. My plant is in a building 50 feet wide by 200 feet long made of blocks. It has many doors and windows in it that are open in the summer time. The blocks that are near the draft dry out a little faster than the others and discolor the most. You can take any brand of cement, I don't care whose it is, put your blocks in a steam room and cure them, and you will get a perfect color.

Speaker's Name Unknown—A number of years ago I had the same difficulty as this brother and it is not right that he should be turned loose without being set right. Don't get the idea that you can use any brand and that you have made a better test than the men who have put their few hundred thousand dollars into the manufacture and their reputation depends upon their turning

out a good article. I don't want to knock on any lumberman but from my experience in Illinois, don't buy from a lumberman. Buy of the men that have their hundreds of thousands in mills. You demand a good grade of cement and then if you want a special cement for a special work there are mills that will give you that grade. You want to know your business but don't think that with a couple of months experience you can come to a convention and have all the necessary information to decide upon a good article. For, Mr. Chairman, a good cement with a man of limited experience, nine times out of ten, will produce a poor article, because the cement business is one of little points and every one of those little points is vital and men that are in the business understand that. It is the little points that you want to pay attention to.

Mr. D. R. Warburton—I am somewhat interested in the lumber business. Since coming here we find that the machine men are working the lumberman, giving him something they know nothing about and intimating that the lumbermen are trying to gull the public on the cement they sell. It has afforded me a good deal of pleasure to sit here and listen to it. We have been trying to make an honest block. I have the pleasure of being just a few yards from our President and I have not heard him say we are attempting to swindle the people. Our lumber convention meets in Marshalltown the 23rd of the month and we will be pleased to have you all attend.

Question—I have as much faith in the retailer as in the manufacturer. I want to say it is the manufacturer who adulterates the output and not the merchant who sells it, as a rule.

Mr. W. D. Faus—I will tell you a little experience I had a few years ago to illustrate that it is not the cement but the user that is to blame for poor results, so it is not the fault of the lumberman always. A few years ago in a town not many miles from here a man bought a barrel of cement from a lumberman. That was when we used imported cement, Germania cement it was called. He used half the barrel and returned the balance refusing to pay for it, and for several other barrels that he got before, on the ground that it was no good. I happened to be doing work in the town at the time and the dealer told him not to unload the cement but to take it up to my work and let me use the balance of the barrel and if it was not all right he need not pay for the cement. At that time I was using the Germania brand. It was considered one of the best brands. I used this cement in a little special batch by itself right with other cement and it proved perfectly satisfactory and just as good as any work that was being done at that time. The man had to admit that

he did not know how to use the cement and consequently paid for it.

Question—I should like to ask how long after cement blocks are made this time of year before they can be put out.

Mr. Schifferdaker—I have tried it in a number of ways. I have never lost a block and have put them out the next day. My advice to make a good block would be to keep it in for at least three to seven days. Seven would be better but still three days, if you do not use a block the first thing in the spring when it thaws out, will be all right. After being thoroughly cured and kept in a temperature of not below 54 degrees in the whole building day and night it will stand all the freezing that is usual if a good Portland cement is used. Of course I was very particular always to use the best known brands. I have never tried any new ones or anything else I didn't know anything about.

Question—Do you sprinkle your blocks you make now?

Mr. Schifferdaker—They were sprinkled regularly, soaked down and kept wet. They were in the house from three to five to seven days before they were taken out. I made over 50,000 blocks the first year and I am safe in saying that over two-thirds of them went out the third and fourth day and I have made good blocks.

Question—How many days after you make the blocks do you think it necessary to sprinkle them?

Mr. Schifferdaker—In the first place water should be applied to the mixture when you mix your block, all that you can possibly get in the sand and not have it stick to the mould. If you are going to make a tamped block it will require less water and less sprinkling. You need only sprinkle it once afterwards, being all that is necessary to insure a good block; still it would be better if it had more water because water is an essential in the maturing of cement; that we all know, but it will make a block such as I sent Professor Marston at one time, one of the first blocks I made—four years ago. If he remembers it stood a test of 48 tons, I believe, to the square inch under crushing pressure. It was pretty compact. Probably Mr. Marston will bring out some of those facts himself. You may take your block out in three days if it was well watered when first made.

Question—Can it be sprinkled too much?

Mr. Schifferdaker—No sir. I am quite a water dog but I was born just over the line from Missouri and would have to be shown.

Mr. Carlon—I experimented some last winter on putting blocks out. We made a practice of not putting our blocks out under a week this time of year, keeping them wet and allowing them to dry out before we put them in the yard. In wetting, as

[illegible] water [illegible] we wasted the blocks [illegible] little water [illegible] degrees below zero [illegible] brought [illegible] a [illegible] That [illegible] would advise [illegible] not to put [illegible] them plenty of [illegible]

Mr. [illegible] I was making blocks up [illegible] of heating. We [illegible] afternoon when it turned very cold and [illegible] the stuff sit there until spring. [illegible] were made the day before this freeze were carried [illegible] and did not show any evidences of being hurt in any way but [illegible] made that day cracked as soon as they thawed in the spring.

Mr. Stevens. The dry concrete stands more pressure than the wet concrete. That has been our experience and there seems to be less trouble with the strength of the concrete than with absorption. 1 to 7 won't absorb nearly so much water as 1 to 4. We are making our blocks 1 to 7 and never wetting them after they are made. We have the best of luck with them and all are uniform in color.

Question. Do you make yours with a tamp machine?

Mr. Stevens. No, we slush them.

PRACTICAL CEMENT TESTS FOR THE CEMENT USER.

JOHN W. DICKINSON, *Chicago.*

To the President and Members of Iowa Cement Users Association:

It is appropriate that we meet in this city for it is not only the geographical center of one of our greatest and choicest commonwealths, but this noble institution which has so hospitably welcomed us has been through its professors a leader in advancing the use of cement in engineering work. Again we join in spirit [illegible] the body of students and teachers, to give of our [illegible] suggestions and instruction, and we [illegible] labor and investigation by [illegible] be solved.

[illegible] along which improvement is [illegible] cement test for the cement [illegible] reliable method [illegible] I think we can [illegible] selves.

[illegible] the complete [illegible] not too lightly

esteem those who have given years of useful service to the investigation of Portland cement, determining the best proportion of the components for highest efficiency, and evolving and establishing the present specifications. So while advocating all the scientific tests and paying grateful tribute to Dyckerhoff, Michaelis, our own Newberry and many others, for their extended and unselfish labors in the interest of manufacturer and user, our present aim is for a simple and sufficiently reliable test, readily available to the cement user himself.

It is an easy matter to take half a pint of cement, mix with water, trowel into cakes and let them either dry out or harden as the case may be. But to give our results any determinative value the following fixed procedure is essential. First, the cement must be thoroughly mixed with water, approximately to the consistency of the top finish of a sidewalk just before it is ready to trowel. This mixing must be thorough, lasting at least two minutes, and the cement rounded into pats of a compact form on glass or other non-absorbent smooth surface. These should then be covered with several thicknesses of cloth and kept well dampened for 24 hours, the temperature of the air being maintained at 60 to 70 degrees. Better too hot than too cold, but the cloths are to be kept well dampened. This will require some watching providing the room is warm. At the end of 20 to 24 hours immerse the pats in water, the temperature of which is not lower than 60 degrees. Good cement will show a satisfactory hardness at the end of three days, although it will be quite safe to commence using should the pats be firm and fairly hard at the end of the first 24 hours. Examine the pats from day to day, they will harden rapidly the first four or five days. Observe carefully any tendency to warp or crack. Should these defects appear reject the cement. While it is quite probable such a cement might be unobjectionable for many kinds of work the best cement will not warp, check nor crack under this treatment.

I anticipate two possible objections. First, that we do not use cement neat and that our pats may show up well and yet the cement prove unsatisfactory in the mortar or concrete. There is a fixed ratio between neat and sand tests, and any cement that gives satisfactory results neat will show the same relative results when mixed with sand.

The second objection that might be raised is that I require certain treatment and temperatures not obtainable in actual work. To this I will say, if your work is to be the best, conform your practice as far as possible to that used in handling your test pats. First, by thorough mixing. This is inadequately done [illegible] out of every ten, and in the majority of cases great loss is sustained by getting only a proportionate value from the cement

[illegible] insufficient mixing. Cement is left in contact with cement rather than to perform its true function of simply bonding together grains of sand. If it is so important to thoroughly mix the water and cement for our neat tests, how much more essential to have this mixing thoroughly done in our actual work after the aggregates have been added.

Regarding my demand that the pats be kept covered with damp cloths, and, whether in air or water, both to be at 60 degrees or over, I will say that our testing is to show the value of the cement under favorable conditions. Then should partial failure in the actual work result we must look to other causes than to the cement manufacturer. We should conform our practice as far as possible to conditions most favorable for obtaining the highest results.

From the more than twenty-five years that I have been engaged in the cement business, during that time having been connected rather intimately with some thirty different brands, I have seen very, very little poor cement. Nearly all the unsatisfactory work has resulted from other causes, such as insufficient mixing, lack of water at the proper time, or, as in the usual failure of sidewalks, separation of the top from the concrete. The bottom course was too dry when the finishing coat was applied, which effectually prevented a bond of the whole. Follow with the top as soon as possible after the concrete is in place.

Unfortunately for the block industry the present requirements of the machines demand an exceedingly dry mixture, although I believe that many could use a wetter mixture than they now do. The form of the block and method of stacking both tend to cause the block to dry quickly. It is best therefore to use as wet a mixture as possible and to keep the blocks well dampened for three or four days.

We sometimes hear the query, "Will Portland cement set under water?" The answer is "No, except under a few certain conditions." It is equally true that cement must have water, and plenty of it the first three days. And let me emphasize, put the water [illegible] your mixture if possible, as an ounce *there* is worth [illegible]

[illegible] rapidly and is constantly demanding [illegible] materials as well as men. And certain it is [illegible] take the position in building and [illegible] is coming, it must be manipu- [illegible] highest results. I cannot refrain [illegible] block manufacturer. I believe [illegible] in the use of cement blocks [illegible] a great improvement [illegible] of manufacturers. We

are handicapped by our inability to use a wet mixture, but a marked improvement is possible by the use of care and intelligence in selecting the aggregates. Our blocks are far too porous, and we must make them more solid by filling the voids. This is impossible by a mixture of one part of cement to four or five parts of the aggregates when the voids in the aggregates approximate thirty-five per cent. Select and mix the aggregates by using coarse, medium and fine in such proportions as will reduce the voids to approximately twenty per cent. This is readily ascertained by the weight of the aggregates, which should not be less than 120 pounds per cubic foot, and it is possible to bring them up to a weight of 125 or even 130 pounds per cubic foot.

I am a firm believer in the use of fifteen per cent of hydrated lime. This gives very beneficial results in strength, and besides so fills the voids that a solid block of concrete is produced. It is essential that the voids be filled by the addition of fine material of some sort; and, as I have said, I strongly advocate the addition of fifteen to twenty per cent of hydrated lime.

Notwithstanding the marvelous development of the block business during the past year, the growth will be still more rapid when a method of using a wet mixture is devised. Then the blocks will be solid and relatively non-absorbent. Is this impossible? There are many that know not the word, but will answer as Shaftsbury answered his king,

"If difficult it is done,
If impossible it will be done."

Let us then by steady improvement go forward and occupy the promised land which is so magnificently opening before every progressive user of Portland cement.

DISCUSSION.

Consideration of the advisability of using 2 to 10 percent of hydrated lime to fill the voids in cement block and concrete mixtures by Messrs Dickinson and Seafert.

Mr. Carlon—I must disagree with Mr. Dickinson on lime in cement. It may be all right, but still I am from Missouri and will have to be shown.

Mr. Dickinson—Did you ever try it?

Mr. Carlon—I have found by experience with efflorescence that I don't favor using any lime.

Question—Did I understand the man to say that a cubic foot of rock would weigh 165 pounds.

Mr. Dickinson—A cubic foot of rock will weigh about 165 pounds. You would be surprised to see how closely the different

[illegible] rock will run in weight. Now whenever your aggregates [illegible] than 105 pounds it simply shows that you have that much [illegible] as I said I think the average sand and gravel will not [wei]gh 105 pounds, or short of [illegible] pounds, giving from 55 to 60 [pou]nds of hole, nothing to fill it up with, say 16 or 18 percent of [illegible]

Now here is the proposition. Supposing we had a dozen [illegible] of rock the size of [illegible]. Does anyone tell me that that could not have been incorporated in that amount of rock with no effect? Instead of a measurement of [illegible] we would have a measure of [illegible]. Would not that have been just as good for a certain class of work?

Mr. [illegible]: What have you to say about the lime?

Mr. [illegible]: Well, I have the greatest respect for Mr. Carlan's opinion. He is a practical cement book man and has made a success of his business and possibly he has gone into this lime question. Why [illegible] I don't know but practical tests are against Mr. Carlan. Several of us were at Milwaukee [illegible] Professor Newberry on that question. He stated positively that the addition of [illegible] percent of lime will [illegible] not only showed no bad effects but I might say reduced the amount of cement that [illegible]. His tests included a series [illegible] showed that nothing but [illegible] results. That was up to [illegible] percent and I would not feel [illegible] percent but up to that [illegible] believe that [illegible] work would be better.

[illegible] of the aggregates [illegible] the amount of cement [illegible] aggregates first?

[illegible] the weighing of your [illegible]

[illegible] any tests?

[illegible] aggregates are per cubic [illegible] of the voids as far as [illegible] best to use ag[gregates] [illegible] is the weight of [illegible] there so you will [illegible]

[illegible] sand to fill your [illegible]

[illegible] one size of sand [illegible] would still be other [illegible] You have prac[tically] [illegible] sand and gravel. To fill [illegible] of cement. If you [illegible] pounds per cubic foot you

have very good aggregates. If you can reach 130 pounds they are all the better for that extra five pounds weight.

Speaker's Name Unknown—Mr. President, in regard to the moving of blocks outside and how quickly that could be done. The block can go out of doors as soon as it is permanently set, which is after about 20 to 24 hours, unless it is sprinkled. As long as you keep sprinkling the blocks the water goes right to the center. On account of the voids you don't want that block to go out in that shape, no matter if it is three weeks old. But if you don't propose to sprinkle it any more, even in late spring or early fall when the atmosphere is damp, the block can go out safely in twenty to twenty-four hours. It can go out in winter in the same time if the block is not wet through. It is simply a question of taking it out as soon as the cement is set.

Mr. Dickinson—The slower it dries out the better.

CEMENT BRICK.

F. A. B. PATERSON, *Fairmont, Minn.*

Cement brick, like cement block, are here to stay; and if the manufacturer will use the proper proportions of cement and sand, with thorough mixing and proper curing, success will be his under conditions which will be hereafter touched upon under different headings.

The question has been asked the writer many times, "Will the cement brick and block last?" The question is a legitimate one, and until some of the manufacturers alter their mode of making both brick and block, the question will continue to be asked. I am sorry to say that many failures are caused by the manufacturers of cheap machines sending out literature that misrepresents and makes believe that if their machine is purchased the buyer's fortune will be made. That is not the only harm they do, for they send men into the country to sell these machines, who know nothing whatever of the ingredients of cement, or of the proper mode of mixing or curing. These men should be experts, able to instruct as well as sell.

"What is a clay brick?" It is but earth mixed and burned. "What is a cement brick?" Stone, composed of thousands of small particles, which are mixed with and bound together by Portland cement.

When your competitor talks "clay brick," in comparing the two, you have all the argument on your side, cement brick not only being fire proof, but having ten times the lasting qualities. Cement brick compare with the best hard pressed brick, and should not be classed with the common clay brick.

I have heard architects refer to cement brick that were made 1 to 5, and say that they absorbed too much water. Of course they will absorb water. So will any brick. The writer tested two brick; one of cement, made 1 to 5, and the other a clay brick made at Mankato. The brick were placed in separate tins, 1½ pints of water poured into each tin, allowing the brick to remain immersed for one hour. They were then taken out and the water remaining was measured. The clay brick had absorbed one-third more water than the cement brick.

The cement brick is recognized by competent architects as the only material that will make a building fire proof. I can refer you to that artistic building "The Armory" which is being built at Minneapolis at a cost of $150,000, and is being constructed mainly of concrete and cement brick.

Make a high priced good brick rather than a low priced inferior one. The public will always pay a good price for a good article, when they know they are getting their money's worth. Those who are contemplating the manufacture of cement brick should carefully consider:—

First, the cost of the cement and sand.

Second, proper machinery to handle the output, and,

Third, competition and market for the product.

Cement—Any of the standard Portland cements will answer for the manufacture of the brick.

Location—In considering a location for the manufacture of cement brick, many things are to be taken into consideration. The first question is,

"Will the business pay a fair rate of interest on the money invested?" One of the most important questions also is the availability of an ample supply of good sand at a sufficiently low cost, that the cement brick can compete with other brick. Without good, clean, sharp sand, at a low cost, one had better not enter into the business.

Sand—The sand should be sharp, siliceous and clean and free from impurities. The writer has found lake shore sand best adapted for making brick. It possesses more silica and is freer from foreign matter. All sand used should be screened. If bank sand is to be used, it should not contain over ten percent of clay or other dirt mixed with it. If more than ten percent of foreign matter is present the sand will have to be washed until clean water is no longer discolored; but this will add to the cost of the brick. The sharper the sand is the better will be the bond between the grains of sand, and accordingly, the stronger the brick.

Machinery for making cement brick—There are many machines on the market, and, like the block machines, some are good

and some poor. If a hand-power machine cannot be purchased which will exert a pressure of 80,000 pounds or more to the square inch, then the next choice is the hand-tamp machine. The writer prefers the former machine, for he believes better brick can be made where a medium wet mixture can be used. A brick can be turned out that will take less moisture when cured than a dry mixture and one that materially leads in appearance. Under this system of hand power compression a more uniform density is secured by the simultaneous application of pressure to all parts of the brick. The mould is entirely filled before the pressure is applied, a medium mixture being employed which contains aggregates as large as can be consistently worked in the mould or tray in use.

Mixing—This is one of the most important items to be considered, because, without a good mixture, failure will surely follow. A power batch mixer should be employed. The first cost is a minor factor, when the saving of labor is taken into account, and the fact that a greater uniformity is obtained in the mixture. To find the proper amount of cement to be mixed with the aggregates of sand on hand, I would advise the water test method, which will enable the maker to know as nearly as possible the proportions of fine and coarse sand to use so that the aggregates will fill the voids. The method is to pour into a glass or jar filled with fine and coarse sand, enough water to cover the contents. Drain the vessel and the water received will approximate the amount of cement to be used. It should be borne in mind that water containing much dirt or foreign matter is detrimental to the cement. Use clean, soft water, if possible.

Now, that we have the materials together, we must decide what proportions of cement and sand to use. A good brick can be made of a mixture of 1 to 5, but I prefer a mixture of 1 to 4. A 1 to 5 brick made on a hand power machine giving 80,000 pounds pressure per square inch, will, when properly cured, have a compressive strength of 2000 pounds to the square inch. It takes two barrels of cement and 1½ yards of sand to make 1000 brick 1 to 5. Cement brick made as above have five times more compressive strength than common clay brick.

In experimenting with a mixture of 1 to 3, two batches were made with the same proportions,—one a so-called dry mixture and one a medium wet mixture. Both batches were made December 29, 1905. At the end of a month the brick from each batch were placed in separate receptacles and a pint of water poured into each. At the end of an hour each brick was drained and the water remaining carefully measured. This test showed that the brick made of the dry mixture had absorbed one ounce more water than the brick made of the medium wet mixture.

[illegible] machine will allow [illegible] whether the mix- [illegible] mixture [illegible] mixture [illegible] present in the [illegible]

[illegible] I have no trouble [illegible] are made of the medium [illegible] I have found [illegible] per cubic foot. The [illegible] I have used [illegible] foot and again with [illegible] nearly double that amount for the [illegible] spent in experimenting will be [illegible]

Curing [illegible] has been written on this subject and I believe that the *average maker does not* give it the consideration it [illegible]. Uniform conditions must be maintained to gain the best results. The dry mixture process requires somewhat different treatment than the medium wet mixture. A brick that has attained its final set and is then placed where the hot wind and sun can strike it will not possess the strength and durability of the brick that is placed in a shed away from wind and sun, where the chemical reactions necessary for the crystallization of the silicates of lime, etc., are permitted to progress uninterrupted. For instance, the brick that is made of the dry mixture will require more water and a longer period of wetting than the brick made of the medium wet. To get the best results (from the experience of the writer) the brick after reaching the final set which should require from two to four days according to the temperature and season of the year, should be taken to a drying shed and burlap or coarse slough hay placed over and around them. They should be thoroughly wetted down and not allowed to become dry for a week. Better results will be obtained in this way than by placing the brick where they are exposed to sun and wind and then depending upon some one to occasionally wet them down with no stated time for so doing.

The two brick previously referred to with which I experimented to determine the amount of water they would absorb, [illegible] side by side. The brick made of the dry [illegible] half of the top surface. The temperature [illegible] in which they were dried was 65 to 70 [illegible]. At the end of three days both brick were dry to all [illegible] the one which was covered by the

tin still retained its natural color, while the part that was exposed to the air was covered with alkali and other chemical salts. There was no change whatever in the brick made of the medium mixture.

I trust this subject will lead to discussion, so that we may learn further from others' experiences.

Cost of Manufacturing—Will vary in different localities. Both cement and sand cost more in one place than in another. Figures for the cost of manufacturing brick to be found in the literature sent out by most of the machine manufacturers are much too low and are misleading. The cost of making 1000 brick without adding interest on the money invested or other incidentals, will vary according to the price of cement and sand. I believe a minimum estimate would be about as follows:

1000 brick, made 1 to 3—

3 barrels of cement	$6.00
1 yard of sand	.35
Labor	1.75
	$8.10

1000 brick, made 1 to 5—

2 barrels of cement	$4.00
1 1-4 yards of sand	.75
Labor	1.75
	$6.50

The cost of clay brick in some of the states may be of interest. The average price is $5.97 per thousand. The highest price, $8.92 per thousand, was obtained in Wyoming; the next highest, $8.17, in Delaware; the lowest price ruled in Kansas, where brick were sold at an average of $4.39 per thousand. Forty-eight states produced common clay brick, valued at $51,768,558.

DISCUSSION.

Question—I wish to ask the difference in weight between the sample and clay brick.

Mr. Paterson—This brick weighs 3¼ pounds. The clay brick is lighter.

Question—What is the size of your brick, please?

Mr. Paterson—It is a little larger than the ordinary brick. 8x2¼x4. Some one asked should we expose it to the air in curing or should we cover it up and prevent the air from get-

ting to it. There is some argument in favor of not exposing it to the air, but that is a question for each manufacturer to decide.

Mr. Schifferdaker—How are you going to keep the air from it? Can you do it by covering over with burlap or have you got to enclose it in an air-tight chamber?

Mr. Paterson—I wish myself to find out if there is any way whereby it can be cured to prevent the efflorescence coming out.

Mr. Seafert—Why do you recommend soft water?

Mr. Paterson—Because I think soft water is better. It is generally purer than water that is gotten out of "any old place." With hard water you are likely to get foreign matter in it that you don't know anything about.

Dr. S. W. Beyer—Mr. Chairman, I would like to suggest a possible remedy for the efflorescence. I do not know anything about cement brick from a practical standpoint, but I know that with clay brick they can often prevent the efflorescence by what they call "facing," setting the brick face to face. It has occurred to me that it might be a case of preventing the water from evaporating; it would not leave the efflorescence that comes on an exposed face. I wonder if any of you brick men have tried "facing" to prevent efflorescence. That seems to be quite successful in ordinary clay brick.

Mr. Carlon—Over on the Iowa river this summer they were working at the east end of a bridge putting in concrete. I noticed the stone piers that I suppose had been there for thirty years were just as white as snow and if you will notice the top of this building, it is covered with efflorescence now. I don't believe there is a man living that can tell the cause.

Mr. Miracle—Three barrels of cement with a mixture of 1 to 3 would make 1000 brick. I have been making a brick that is a trifle larger than this brick, 5.2" and my experience has been that it takes three barrels to make 1000 brick of 1 to 4 mixture. The reason I bring this up is because I have seen literature telling how to make brick at $3.50 a thousand. It is certainly preposterous. I want to emphasize that it is the quality rather than the idea of cheapness that we wish to impress on the mind of the public.

Mr. Metzgar—There is a matter that I want to bring before this convention before we adjourn. I do not want to put it in the form of a question but I want to submit the practical suggestion. It was brought up here last year and relates to the building and construction of sidewalks. There is no law of Iowa that gives the contractor the right of action or redress against

property owners for the construction of sidewalks. I wish we could have a committee appointed to draft resolutions.

The convention adjourned to meet at 8. P. M.

EVENING SESSION, THURSDAY, 8 O'CLOCK.

The President called to order and, after music by the College Glee club, introduced Mayor Sheldon, of Ames.

MAYOR SHELDON'S ADDRESS.

Members of the Cement Users Convention:—

I assure you that it is a pleasure to tender you a hearty welcome and to extend the freedom of our city during the days that you are to take up the matters of interest to your association. Yours is an industry that is forging to the front in many lines of a permanent character to the well-being of our state, and country as well. Cement is being adopted in many structures of permanency, buildings and sidewalks, and in the construction of bridges of large proportions. Although at present I presume the use of cement is in sort of an experiment stage, it has every promise of being among the very best materials for constructions of that character.

We feel it an honor to have you meet with us in our little city which is getting to be quite a convention city. We regret that we are limited in some of the necessary accommodations for taking care of conventions of this kind, but our people are generally liberal in the way of throwing open their homes and I trust will endeavor to see that everyone is cared for.

We have what we regard as a pleasant and desirable location and community for a resident city. We make the claim, and I think without fear of successful contradiction, that we are more largely advertised than any other city of our population in the land. It is not on account of any commercial interest that we have or any manufacturing interests. It is simply because it is the seat of the Iowa State College of Agriculture and Mechanic Arts, the greatest institution of its kind in the country, and I think truthfully said, in the world. The benefits that we are deriving from lessons that are learned are just beginning to bear fruit in many directions. The interest that has been taken along the lines of agriculture, and I predict as truthfully said in future years as in the past, has added more to the value of the crops in the state of Iowa than all the money that has been expended in the way of appropriations for the building up and support of this institution since its organization. I think this is conceded, in fact, there is no doubt of it; and still that work goes on. It

has been demonstrated that the institution stands in the very forefront in the matter of agriculture and of animal husbandry. The newly equipped Dairy Building is the best of its kind in the United States. The same is true of the Division of Engineering. The equipment of this division is considered to be the equal of any, if not the best, west of Chicago. We are proud of the institution, proud of it in the different departments, proud of the men it has sent out, proud of the record they are making for themselves, and when they are making a reputation for themselves they are adding glory to the institution from which they have gone out. We are equally proud of the boys that are with us at the present time, and the girls as well.

I never miss an opportunity to speak a good word for the Department of Domestic Science, for I am considered to be a sort of a crank on that subject. I contend that there is no one department in this institution that is doing more for it and for the homes of Iowa, and the homes are the foundation of everything that is good, than is the Department of Domestic Science.

This great institution, as I have said, is just beginning to bear fruit. The buildings that have been put up are of a permanent character. Arrangements are now under way to provide for the further needs in the way of buildings and there seems to be, possibly is, a disposition on the part of some members of the legislature to withhold appropriations which, if it is done, cannot but cripple this institution. There is a demand for buildings of permanent character such as have been put up recently, and an urgent demand for them. There is a demand for an auditorium, an *urgent* demand for a building of that kind. There is a demand for a hospital and last but not least, there is a demand for a home for the Department of Domestic Science. I hope that each and everyone of you that has any influence with our Legislature will use your influence to see that the needs of this institution are provided for.

I think I had the honor to extend a welcome to this association on their previous meeting here and some member criticised me a little for not bringing out the city marshall and police force to make them acquainted with the "powers that be" in the city of Ames. I think that I corrected that matter by expressing my opinion that it is entirely unnecessary for this association to become acquainted with our police department. We expect to do [illegible] we have by all the associations that have met with us, and that is to depend upon the manhood of the bodies to preserve [illegible] never been disappointed. We have adopted [illegible] body and they have never disappointed [illegible] say without fear of contradiction that there [illegible] the land where there is better order than

prevails among the student body of this institution. They have always maintained order for us and we expect they always will.

I assure you again that we feel honored to be favored with your presence here and I hope that you may realize all the benefits you have anticipated in meeting here. In conclusion I want to say in the language of one of the former heads of this great institution, whose memory we all revere, "I bid you a hearty and thrice welcome."

ADDRESS OF WELCOME BY PRESIDENT A. B. STORMS OF THE IOWA STATE COLLEGE.

Members of this Convention or Association:

In behalf of the college I am somewhat embarrassed by the generous words of our mayor. As soon as he goes out of the room I will return the compliment by remarking that no town in a college community has a better mayor than Ames. We cannot help keeping good natured and keeping good order with such a chief administrator in our midst.

You gentlemen have gathered here for business rather than for words that may be more or less formal. I suppose there is a sort of an obligation upon your Program Committee arising from past precedent to ask for addresses of welcome but I also know that you are quite likely to be bored by such an address if it be long continued. I want simply to express by personal pleasure at the fact of this convention assembling here and also in behalf of the college to express our pleasure and our welcome. You gentlemen have not come here as philanthropists and yet I can see that no men are doing more for the good of their kind than those who are actively and intelligently interested in the development of the natural resources of the country. The time is rapidly passing when we can rest content with a sort of natural blundering method of agriculture alone. There must not only be the improved methods of agriculture which are being introduced for the conservation of the fertility of the soil and for the better use of the fertility which is being exhausted or used, but there must also be for this development in agriculture the accompanying developments that come in manufacturing interests.

You perhaps represent in your assemblage here tonight an industry that has had a more wonderful and rapid recent growth than any other. Professor Beyer assures me that his chart, which you will have the privilege of seeing later, will illustrate something of this development. I think he says that the production of cement has increased from three-fourths million barrels to nearly thirty millions of barrels annually in the past twelve years. The improved uses or the extension of the uses for the material in which you are chiefly interested is a matter of the greatest

[illegible] the vastest interest, not only to you, whose business [illegible] affected, but to all of the country as a building material, [illegible] other purposes to which cement is being put.

[illegible] you tonight, then, in the name of the Experiment [illegible] we have two Experiment Stations located here by [illegible] of the state. The older one is the Agricultural Experiment Station which has been in existence I know not how many [illegible] perhaps dating back with the first act of the National [illegible] making annual appropriations for the establishment [illegible] stations in several states, and now supplemented somewhat by the state assistance, to experiment along the lines of agriculture. As you perhaps know, this Experiment Station and the other of which I will speak in a moment, have no direct connection whatever with the college and its work. The station staff are employed and are giving their time, or in cases of men whose time is divided, they give a portion of their time which is not demanded for college work. More recently there has been established here an Engineering Experiment Station. The results of the efforts of its staff and the problems which they are seeking to solve are more directly related to the interests which are near you. We feel that their two years work shows very good results, rather remarkable results, and some very interesting experiments are under way and in contemplation. If the legislature shall see fit to provide for the continuance of this work in the future, and we scarcely think that it can be otherwise than very probable, we believe that most valuable results will be put forth. So, in the name of the two Experiment Stations, and perhaps I should say particularly of the Engineering Experiment Station, we bid you welcome. Also in the name of the college, for that stands distinct as an institution along side of the Experiment Station; and in the name of the 1200 young men and more who are gathered here in the different departments of this college and are busily at work, aside from the young women, which make over 1400, and the short course students in the Agricultural courses, bringing the number up to from 2000 to 2200 if they were added. In their name we welcome you. We assure you that our students are deeply interested in the very problems and questions which are interesting you, particularly the students in Engineering. Our methods of education, of course, and the subjects of the studies that are pursued are bringing the students very vitally into relation with the actual business of the world and the actual and vital interests of life that they will have to face when they leave the institution and go by themselves.

It is a matter of great interest that we find our alumni wherever they go doing useful work and finding that the world has

something for them. The senior class last year, when things were not so vigorously progressing in the business world just at the close of school as they had been some time before, wondered whether they were going to find anything to do. They did not wonder long. I know of no one that has not found his hands full of very interesting and useful labor. As a president of a great University said in my hearing three years ago as I gathered with other alumni of that institution, "I have gone to every state and territory in the United States and to many countries abroad and I am finding everywhere former students of this institution welcoming me, who are doing the things that need to be done." And so we believe that our students as they leave this institution will be found doing in the world the things that need to be done.

Capt. Bob Evans said to a friend of mine that the best seamen are the land lubbers from the middle west who never saw salt water but who after eighteen months of discipline have become the very best sailors. We feel that the young men who come up from the farms and valleys and the towns of Iowa constitute about the best raw material that can be found on the face of the earth to make successful men. We have great confidence in them and we have reason to have. In the name of the students therefore I am privileged to welcome you for your deliberations here; and also in the name of the Faculty. A more enthusiastic body of men than I find on this campus it has never been my privilege to associate with and I assure you that in their name you are most heartily welcome and many of them are delighted to participate with you in your deliberations. We welcome you to our homes and we welcome you to the site, now vacant, where a splendid hotel is going to stand bye and bye. I thank you.

PRESIDENT COUTTS' RESPONSE.

I want to thank your mayor from the bottom of my heart for the welcome he gave us. I have a good deal of sympathy for the man holding that office and it would not be out of place for me, as mayor from the first best college town in the state to thank the mayor from the second best college town in the state. When Mayor Sheldon comes to Grinnell I shall be willing to change that order.

We as members of the Association should have provided a response to these addresses as a part of our regular program but this was overlooked and of course I will have to take charge of this matter myself. I could not do otherwise if I would.

It was not a difficult matter to thank the Mayor of this town but when it comes to a college man it is an entirely different proposition. I feel a good deal like the boy of whom I read a

... who applied to the Captain for a job piloting his ... the river. "Do you know where all the snags are in ..." asked the Captain. "No sir. I don't know a single ..." "If you don't know where the snags are how can ... pilot this boat down the river?" "I know where ..." I know where the education isn't because I never ... left school a month before I was nine years old and ... but three months after that. Nobody is to blame but ... greatly the lack of it. When my father died, the ... that he left the world was a large family of children, but ... he left what is better than riches, a good name and a ... Christian character. I think that I have inherited a rich ... I am glad I have been able to give my boys a different ... education than I had and I am glad that I have had the pleasure ... privilege of educating one of them at Ames with all these advantages that I can see in this great institution of which I will ... later tonight. I thank you most cordially for the glad ... you have extended.

Music by the College Glee Club was well received, the Club ... twice called back to respond to encores.

Annual Address by the President of the Association, Mr. R. ... Coutts.

Gentlemen and Members of the Iowa Association of Cement Users:

As President of this Association it affords me great pleasure to address you on this occasion. Almost a year ago as the cement users of the state we held our first annual convention in this room. That was a very enthusiastic and successful meeting, and in my opinion served to give the cement industry quite an impetus throughout the state. I think there is no way by which we can advance the interests of this great industry more than by these annual gatherings.

We come here to discuss our successes and failures, to help each other over the pitfalls that surely lie in the way, and to engender a little enthusiasm on the subject as a whole. I am a strong believer in enthusiasm (I don't mean fanaticism). I believe in religious enthusiasm, political enthusiasm and I also believe in industrial enthusiasm. I am a firm believer in the magnetism of a forceful character, for "energy of character has always a ... to evoke energy in others. It acts through sympathy ... the most influential of human agencies. It has been well said that the zealous energetic man unconsciously carries others ... he exercises a sort of electric power which sends a ... fibre and flows into the nature of those about ... we will only give this energy of character ... throughout the various sessions of this meeting we

will catch the enthusiasm and by the time we get ready to adjourn we will be unanimous in voting the convention a grand success.

It would be useless for me to remind you of the greatness of this industry, of course it is not new. Cement or the use of it as a mortar dates back 4000 years B. C., but as far as history informs us it seemed to have been enjoying a "Rip Van Winkle" sleep for nearly 6000 years. Its resurrection seems to have taken place in Europe about 1855 and for a period of about twenty years it looked as if Germany and England had gotten a "corner" on its manufacture; but about 1872 the ingenuous Yankee got the idea in his head that he could make Portland cement too. The progress made along this line has been so great as to make it almost incredible. We first crept, then we walked, now we run. In 1872 we manufactured 300 barrels, in 1890 we made 335,000 barrels, while in 1905 we manufactured according to reliable authority almost 27,000,000 barrels. Suppose we pause for a moment to consider how much cement that would be. As cars are usually loaded it would make 270,000 car loads. This would make a train that would reach two-thirds across the state of Iowa from east to west. This is no overdrawn statement, but one that can be substantiated by actual proof.

We live in an era of progress, and there is no industry that has made more rapid advancement in recent years of which I know anything than has that of cement.

To so many purposes can the use of it be applied. It can be used in ways and for purposes of which we nor our fathers never dreamed, and yet it is but in its infancy. It has in a large measure already supplanted the use of stone, brick, iron and steel, and from the present outlook, will before long take the place of wood as a building material. A friend of mine who is in the lumber business informed me the other day that there had been an advance of fully 25 percent in the last year on all grades of lumber in Iowa, and upon investigation I find that this state of affairs is not confined to Iowa, nor to the northern states. A gentleman from North Carolina writing to one of our trade journals recently, makes this statement: "We are up against a building proposition good and hard. Here in the south at present the demand for yellow pine for the northern market is simply enormous, and the price has gone up so as to make it almost prohibitive for local consumption; besides that we have no stone or brick nor even clay to make brick, in fact we have nothing but sand." When I read this statement I felt as if here was a community that stood in need of our sympathy, but on consulting a map furnished by the "Concrete Age," showing the location of cement factories, I noticed that over the state line north in Virginia there

were four factories, and south of the line in Georgia were three; so with plenty of sand on the ground and cement near by all they need now is a good bright member of this Association to invade that territory, sell a dozen good cement stone machines, and show them how to use them and the troubles of our North Carolina friend will vanish.

Of course we may speculate all we please but the stern fact still confronts us that something will have to be found that will take the place of lumber as a building material so far as that can be done. My own opinion of the matter is that the solution is right here in Portland cement. As to how far the lumber merchant is responsible for this state of affairs I am unable to state, but I want to call your attention briefly to the attitude of the cement dealer towards the consumer during the famine through which we have just passed. Some time ago I received this letter an extract of which I will read you:

"Now about the middle of February I am making arrangements to hold a Tri-State Cement Users Convention for the sole purpose of seeing if we can't come to some kind of an understanding as to what to do with these Cement Mfgs. I now have the assurance of the National President and Secretary and all the Vice-Presidents to help push the thing along. This convention is for the sole purpose of trying to get together and see if we can't manage some way to handle the Cement Mfgs. It is not a Block or Brick Machine Mfg. Convention but a Cement Users solely. We do not care whether there is a Block Machine man here or not. It is the Cement I am going after. Now you being the President of the Iowa Association I would like to have an expression from you by return mail as to what you think of it.."

Now I think the tone of this letter is very unkind and uncalled for, and I so answered the writer. I think that great credit is due the cement manufacturer for keeping the price in line considering the enormous demand made upon him for cement during the busy part of the season just past. There was a time within the last four months when all he had to do was just to ask his price and the only question that would be asked him in return would simply be "can you deliver the goods?" It is true that the price was considerably higher during the latter part of the season than in the early part, but if the cement man had been so minded he could have demanded double that advance and sold almost as much as he did.

Pardon a personal illustration. During the month of September I discovered one day that I had only about twenty-five sacks of cement with work enough requiring immediate attention that would take several hundred sacks. I had orders in at two

different mills and was looking for a fresh supply every day, and just as I was almost entirely out I received a letter from each mill. One was crowded to death with orders, the other could get no cars in which to ship the goods. Well, as every cement dealer in town was about as nearly out as I was the situation looked gloomy indeed. The first thing I did was to ring up Des Moines by phone and called the largest dealer there and asked if he could spare me a car load but he answered *no*. Well, I said, couldn't you spare me two hundred sacks. No, we are sorry but we could not spare you a single sack; we are away behind with our local orders, and our stock is almost exhausted.

I next went up to the long distance telephone and called up the Marble Head Lime Company in Chicago. Mr. Bishop, Secretary of that company, answered the phone. I said, "Mr. Bishop, I'm in trouble." "What's the matter with you, what can I do for you?" "I'm out of cement." "Oh that's it." "Have you anything en route?" "Nothing en route." "Have you anything on track?" "Nothing on track." "Mill is four weeks behind with its orders and they refuse to book any more at present." "Well," I said, "Have you anything in stock?" "Nothing in stock. Cleaned out." "Then you are about as bad off as I am." As I stood in that booth holding that telephone at a rental of fifty cents a minute trying to think what I should do next, Mr. Bishop said, "Where are you?" I said, "I'm in Grinnell." "Oh," he said, "I thought the way your voice sounded you were in the city. I'll tell you what I can do. If you are not too particular about the price I think I can go out and buy you a car at some of the dock warehouses, and if I can't I will wire you in the morning." I said, "I have some regard for price but the important thing now is to get the cement." Instead of a wire message in the morning I received this letter:

CHICAGO, ILL., OCTOBER 12, 1905.

R. G. Coutts, Grinnell, Iowa.

Dear Sir—As per telephone conversation of this P. M. we have bought a car of Vulcanite cement for you at $1.60 f. o. b. Cars Chicago, and ordered them to ship it to you at Grinnell, Iowa. The cement is in the Lehigh Valley Transportation Co's dock here in Chicago, and they have ordered in a car. If this price is more than you can stand, you may wire us on receipt of this letter and we will cancel the order.

This will make the cement come pretty high delivered at Grinnell, but it is the only car we could find here. We assure you we are not making one penny on the deal; we are paying $1.60 for the cement, same as we have quoted you.

We called up all the cement men here who handle cement in

car lots, and most of them laughed at us for even supposing they had any cement. The facts are, the demand for cement since the 1st of October has been almost as great as in 1902. At that time it went to $2.00 and $2.10 per barrel at the Michigan and Indiana mills and the eastern mills in the same proportion.

Hoping our action in this matter will be satisfactory to you, we are,

Yours truly,

MARBLEHEAD LIME CO.,

Per Bishop.

Now all of this I offer in proof of the statement I have already made that the cement man has used us right, because he could have made us pay $2.50 to $3.00 for this cement if he had been so disposed. I am revealing no trade secret when I say that we as contractors are not in the habit of buying cement during the winter months at a very high premium. If a cement dealer gets your order or mine during what we are pleased to call the period of inactivity he sells it at about what it is worth. But if during the busy part of the season he finds us with "our clothes off" he can just name his price and we can simply let it alone, sit down and let the work go undone, or walk up to the Captain's office and put down the cash. But as before stated the cement manufacturer has showed no disposition to take advantage of our necessity in this direction. In my estimation therefore too much credit can not be given him for his co-operation in this particular.

Another feature of the case I want to call attention to is, that in order to propagate the cement business we don't have to jump on to some other industry and try to tear that down in order to advance our own. At a meeting I attended in January I was considerably amused as well as a little disgusted by a paper read by a devotee of another branch of the manufacturing business, and one not in accord with the one we here represent. The young man had taken a great deal of pains in writing his paper to show that "We are the people;" that the cement men were not only usurping the rights of the brick manufacturer but he was also flooding the market with a spurious article of building material. Now I believe there is demand enough in this great state of ours for all the brick that our brick men can burn, and all the cement stone the cement man can make, and I believe that the best interests of both will be subserved by our "dwelling together in unity."

It is a fact worthy of notice that some of our sister states have got the start of us in the manufacture of cement, but although it is an old saying it is nevertheless true that "They are far behind that dare not follow," and recent discoveries have developed the fact that Iowa has large deposits of material out of

which a superior quality of Portland cement can be manufactured. Her sons have the brains, her capitalists have the cash and it is my prediction that before two years from now we will have at least two factories running in Iowa turning out as fine an article of Portland cement as can be found in the world. Our glorious Iowa takes no back seat. She has got the material, the money and the brains to take care of most any proposition that comes up. She can produce the largest corn, 147 bushels to the acre, and the finest hogs that the world has ever seen, but her skill does not stop there.

In the course of an address delivered by Gov. Cummins the other day the Governor stated that Iowa's superiority to all other states as an agricultural state was recognized, but in manufacturing we are far behind our possibilities. It is a fact worthy of note that while the Iowa farmer stands at the top he is not contented to sit down there. Never before in the history of the state has there been such rivalry among the farmers. The poor farmer wants to become a good farmer, the good farmer wants to become a better farmer. This is a fact beyond question to every intelligent Iowan who pretends to read the current news of the day. We learn from our daily paper that the short courses in corn and stock judging given at this institution in January were by far the most successful ever held. That which was considered successful farming even as late as ten years ago would be considered very ordinary today. I heard Joe Trigg in his inimitable way at a farmers' meeting held in Grinnell a few weeks ago say that the Iowa farmer who was satisfied with less than fifty bushels of corn to the acre "stood sorely in need of the prayers of the church."

If then the farmer is puzzling his brain, spending his time, his money, and his energy to develop the agricultural interests of the state we ought to use the same diligence and zeal in looking after her manufacturing interests, and thus secure her symmetrical development. For quoting Gov. Cummins again "It is not enough that all our power and development shall be along one line if we are to measure up to our possibilities."

To fall in line with the general thought here expressed requires no great original idea from this generation. We have only to build on the foundation already laid for us. Take for example this great institution which has so generously opened its doors to us on this occasion (in fact, it is to a number of the members of its faculty and to their interest and untiring efforts on our behalf a year ago that this organization owes its existence). Now while this college stands for the very best there is in the *field*, the forces it has set in motion for the development of the shop and of the mine have made their influence felt and its name a house-

[illegible] Minnesota California [illegible] and wheat [illegible] our clay [illegible] cement [illegible] and have the same [illegible] of [illegible] corporat[illegible] state [illegible] this respect [illegible]

[illegible] representat[illegible] manufacturing interests [illegible] to supp[illegible] of pr[illegible] shall [illegible] buildings [illegible] materials [illegible] this feature.

[illegible] manufacturing [illegible] departments [illegible] the main purposes [illegible] greater than [illegible] represent[illegible] cement [illegible] has [illegible] more than [illegible] and I presume [illegible] material. A large [illegible] makes us [illegible] besides [illegible] numerous [illegible] the various papers [illegible]

[illegible] congratulate the members of this [illegible] we have enjoyed. I want [illegible] contributed so largely to [illegible] publicly to thank our [illegible] in getting this program [illegible] of the faculty of the Iowa [illegible] and all who have interested [illegible] organization. I trust that the [illegible] cause you all to feel that [illegible] each cement user will go [illegible] personal contact we have had with

each other and more determined than ever to enter upon the work of the coming year, not with the grovelling desire to simply add another dollar to his bank account, but to build up this great industry in this great state by bending all his energies to do the very highest class of work of which he is capable. Iowa is deserving of our very best efforts. So then, gentlemen, let me in conclusion exhort you to go forward, don't be "Standpatters" on this question but get imbued with the *Iowa Idea* which stands for progress, stands for advancement, the Iowa Idea stands for Victory all along the line.

The chairman introduced Professor S. W. Beyer who presented the following paper on

DEVELOPMENT OF THE CEMENT INDUSTRY IN IOWA.

The manufacture of Portland cement in the United States shows a remarkable growth during the last ten years. According to the U. S. Geological Survey the production for 1894 was 798,-757 barrels while the output for 1904 reaches a total of 26,505,881 barrels. Figure 1 (referring to chart) shows graphically the growth of the industry and also the production of natural cement, slag cement or Puzzuolana, and Portland cement imported during the period. It will be noted that the production of natural cement shows but slight variation save those fluctuations which can be explained by the industrial fluctuations of the time. The same is true when imported cement is considered. The production of domestic Portland cement appears to be as yet almost independent of trade conditions, which may be interpreted to mean that the supply does not yet more than keep pace with the rapidly increasing demand. While the production shows a continuous increase the price was more responsive to industrial conditions in general and has changed from year to year. The average net factory prices for Portland cement during the last five years were as follows:

1899 average price per barrel	$1.43
1900 average price per barrel	1.09
1901 average price per barrel	.99
1902 average price per barrel	1.21
1903 average price per barrel	1.24
1904 average price per barrel	.88

Reliable data are not at hand for the year 1905, but enough is known to assert with some degree of positiveness that the domestic production is still on the increase, but the average price has been materially reduced owing to the opening of large plants in the gas belt of Kansas. The cheap natural fuel of Kansas has

greatly reduced the cost of manufacture and to some extent has lessened the price of the finished product to the consumer.

Notwithstanding the enormous growth of the industry and the further fact that Portland cement is rapidly becoming almost a necessity to the prairie states, Iowa has not, as yet, contributed a single barrel to swell the total production.

Soon after the organization of the present Geological Survey, the Director, Professor Samuel Calvin, realized the importance of the then youthful industry and his first paper was entitled "Cretaceous Deposits of Woodbury and Plymouth Counties, with Observations on their Economic Uses," and appears in Volume I of the annual reports bearing the date of 1892. In this paper the Niobrara chalks and associated clay-shales are described and their suitability for the manufacture of cement pointed out. Professor Calvin's paper was later supplemented by himself in Volume III and greatly elaborated by Bain in his Woodbury and Plymouth county reports to be found in Volumes V and VIII respectively. While this information has been available for some years and the district has been visited by numerous interested parties, nothing has been done toward the utilization of the chalks in Iowa. Within the past few years it has come to be generally recognized that chalks and marls are not necessary in the manufacture of Portland cement; that limestones be they hard or soft, providing they are correct otherwise, are suitable for cement manufacture. The recognition of this fact has led to a renewed search for locations favorable for cement plants within the confines of the state and never has the search been so strenuous as during the past year. The Survey and the College have been importuned for information on the subject and samples from numerous points in the state have been sent in for analysis. One factor appears to be uppermost in the minds of those seeking information and that is, "that given the raw materials which will make cement" a cement plant is assured. They do not fully realize that suitable raw materials in commercial quantity is but one of the most important factors in the location of an industry of this kind. Suitable transportation facilities; and cheap fuel suitable for burning the cement are equally important factors and must be taken into account. In fact some authorities are inclined to doubt the wisdom of placing suitable raw materials first in the list of controlling factors. However the factors may be rated, the raw materials are usually the first factors in the problem of cement plant location to receive attention by the average investigator.

As has been intimated before, the eyes of the promoter and of the cement manufacturing world are at the present time focussed on Iowa. A number of causes contribute to bring this about. Iowa is at the present time one of the greatest cement users, and

the increasingly high price of lumber, and other structural materials and the new and varied uses to which cement is being put will increase her consumption many fold; and her position geographically (Minnesota has little in the way of suitable materials or cheap fuel to commend her for consideration in this connection) gives her a commanding position strategetically. A cement plant in Iowa ought to command the markets of the "Twin Cities of the North" in addition to her own domestic trade. Her nearest competitors are located in Illinois, Hannibal, Missouri; Iola, Independence, and Neodosha, Kansas; and Yankton, South Dakota. A factory located in north central Iowa would be protected from the incursions of her competitors by a freight rate of from 12 to 14 cents per hundred pounds; a sum sufficient to cover a considerable portion of the cost of production in the modern cement mills of today, and a sufficient reason why the state is the center of attraction, the "Promised Land" of the cement manufacturer.

About two years ago the director of the Iowa Geological Survey assigned the writer Iowa quarry products for investigation and report. The work has been carried on jointly by the Survey and the Iowa State College and on account of the increasing importance of cement, and in order that the public may have results without undue delay a preliminary report is being prepared on this special phase of the subject. The work has been carried far enough to demonstrate beyond a reasonable doubt that the state can meet the conditions outlined in an earlier portion of the paper. The raw materials in commercial quantities are easily available at several points. Cheap fuel suitable for use in developing the necessary power and burning the product is available over a considerable portion of the state; and last but not least, several points possess almost unrivaled transportation facilities.

It is generally known that most of the so-called limestones in Iowa are dolomitic or at least contain a percentage of magnesia prohibitory in the manufacture of Portland cement. While this is true, there is sufficient limestone low in magnesia to supply all the cement plants of the country. The range in age from the Ordovician exposed at Specht's Ferry, Waukon, Decorah and numerous points in Northeastern Iowa, to the Niobrara chalks and limestones exposed in Plymouth and Woodbury counties. Of the limestones commercially available, the Galena exposed at Decorah and Waukon, and doubtless at other points; the Cedar Valley stage of the Devonian exposed at Mason City, Charles City and vicinity; the Kinderhook stage of the Lower Carboniferous which appears at Burlington, Quarry and Legrand, Iowa Falls and Humboldt; the Upper Carboniferous of Earlham and Peru are the most promising. Suitable shales and clays may be found in the Galena-Trenton at Specht's Ferry, Waukon and

Decorah; the Maquoketa at Kidder and Graf in Dubuque county, Colesburg in Delaware, and Clermont in Fayette; the Lime Creek shales of Mason City, and Rockford; the Kinderhook shales at Burlington; the Coal Measures typically developed at Des Moines, Boone and Fort Dodge and exposed at numerous other points in the Des Moines River Valley; the Benton shales of Plymouth and Woodbury counties; and much of the loess which covers two-thirds of the surface of the state.

Iowa, Illinois and Wyoming coals offer suitable fuel at reasonable cost for the various portions of the state.

Excellent transportation facilities are available at Burlington, Des Moines, Fort Dodge, Mason City, and Sioux City. Reasonably good facilities may be had at numerous other points.

To recapitulate; while numerous points in the state meet one or more of the requirements for a successful cement plant, few indeed possess all of the requirements. Perhaps not more than four points deserve mention in this connection and are as follows: Mason City, Des Moines, Burlington and possibly Fort Dodge.

Mason City, in the judgment of the writer comes nearest combining these factors in a superlative degree. Briefly considered the advantages of this point are: Limestone, almost pure, ranging from twenty to twenty-five feet in thickness, occurs extensively along Lime Creek and lies safely above the water line with almost no stripping over it. Chemical analyses show that the magnesium oxide present averages less than one percent with scarcely a trace of sulphur. Twenty to forty feet of plastic shale is easily available and suitably located to load with the steam shovel. The shale carries some magnesia but when blended with the limestone in the proper proportion for cement is well within the safety limit. Two lines of railway directly connect the city with the principal coal field of the state. All of the mines of this field "shoot from the solid" thus affording an abundant supply of slack and steam coal at minimum cost. Four leading lines of railway with a fifth assured and an interurban line gives the city unexcelled railway facilities. Last and not least Mason City occupies a strategic position geographically. An up-to-date Portland cement plant at this point would be in position to control the cement trade well into the British Dominion to the north, and west at least to the Missouri river, in addition to the Iowa field. A company has been organized recently to build a plant at Mason City. Options have been secured on extensive tracts of the raw materials and a modern Portland cement plant in full operation is assured to the state within the next eighteen months. It is the intention of the present company to install at least a 3000 barrel mill, one of sufficient capacity to supply a large portion of the available field.

Des Moines also is being considered seriously at this time as a possible location for a Portland cement plant. Its splendid transportation facilities, excellent cheap fuel, wealth of raw materials within easy reach and extensive local markets ought to command the attention of prospective investors in the cement industry. Of the other two cities mentioned Burlington is well within the field controlled by the Illinois and Missouri plants and perhaps on this account does not possess the attraction for would-be investors in the cement industries that might otherwise belong to it. Fort Dodge is still a possibility but not enough is definitely known to warrant a specific statement.

At the close of the session, the members were invited to take part in an informal reception in Engineering Hall where a pleasant social hour was spent in renewing old and making fresh acquaintances. Refreshments were provided by the Ames Commercial Club and served by several of the lady students of the College.

MORNING SESSION, FRIDAY, FEBRUARY 9, AT 9 O'CLOCK.

President Coutts appointed the following committees:

Resolutions—L. L. Bingham, D. R. Warburton, Geo. H. Carlon.

Nominations—D. P. Faus, H. F. Carlon, S. W. Beyer.

Specifications for Hollow Blocks—O. U. Miracle, Geo. Gabler, Wm. King.

Legislation—A. E. Metzgar, T. H. MacDonald, H. F. Carlon.

First paper on Development of Cement Block Industry, O. U. Miracle, Minneapolis.

It is with great pleasure, and not without a sense of high honor, that I accepted your kind invitation to address this, your second annual meeting of the Iowa Cement Users Association.

During the year past we have all had many new experiences, and have learned much in this new field, and will certainly profit largely by a free exchange of ideas and experiences at these meetings.

The marvelous growth of the industry during the last twelve months has exceeded the fondest hopes of its most ardent advocates. A year ago our discussions were confined mostly to concrete blocks and sidewalks, outside of the regular line of reinforced work as applied to all sorts of structures from culverts up to and including large bridges, and even office buildings. Many new applications for cement materials have developed, some having reached a practical stage, while others are still on an experimental

basis. Concrete brick, tile, sewer pipe and fence posts have been successfully used during this term.

The concrete brick is destined to play a very important part in the introduction of concrete, as many people will accept concrete in this form on account of its familiar shape and size, when they would be skeptical concerning the use of hollow blocks, or concrete in any other form. So this is a legitimate place for cement brick.

There are many machines on the market for the manufacture of concrete brick, which have met with various degrees of success. Where the factor of cheapness is the main consideration, cement brick often fall short; but in localities where a common clay brick sells from $12.00 per thousand up, cement brick can be made and sold at a very satisfactory profit.

Much misleading literature will be found in circulation covering the subject of cement brick. Some of the figures as to cost of manufacture given in this literature are less than the actual cost of the cement required to make a fairly good product. In the manufacture of cement brick, where appearance is taken into consideration, it is necessary to either face the brick with a finer or richer material, which will require additional labor, or to eliminate entirely the use of any coarse aggregates. Under these conditions as rich a mixture as one part of cement to four parts of sand is indispensable. A thousand cement brick of standard size will weigh 5500 pounds. A mixture of one to four means five parts. Dividing the weight, 5500 pounds, into five parts we have 1100 pounds for the weight of the cement, which is practically three barrels of cement required to make one thousand first class brick. As I have stated above you will find many sets of figures, which have been placed in circulation by brick machinery manufacturers, showing the cost of 1000 cement brick as much less than the value of three barrels of cement. A high class brick can be made however, with the average of machines that are on the market, at a cost of $7.00 to $8.00 per thousand including sand, cement and labor.

Concrete tile for drainage purposes has taken a very important position in the Iowa market during the past year, and many thousands of feet have been laid in different parts of the state. It is a foregone conclusion that, if properly made, concrete in this or any other form will outlast any kind of clay tile when subjected to continuous moisture. By using the medium dry process and a reasonable amount of coarse aggregates it can be made as strong and at the same time as porous as may be desired.

I would not at this time recommend undertaking the manufacture of cement tile for drainage in sizes smaller than 10 inches in diameter because the cost of handling and burning clay tile decreases very rapidly with the decrease in size; but on the other

hand the cost of making clay tile increases with corresponding rapidity as the size increases above 10 inches in diameter. And the opposite is true proportionately of cement plant.

Cement pipe when first molded, unless allowed to remain in the mold, are very delicate, and must be made on a solid floor, preferably the ground or a concrete floor, so the tamping of the joining tile will not injure the freshly made product.

I find the most popular of the large sizes of drain tile used in Iowa are 15, 18 and 20 inches in diameter. Take for illustration 2'x20" tile. These should be made 1¾ inches in thickness. Figuring on a basis of a mixture of three parts of sand to one part of cement, with sand at 75c per yard, labor at $2.00 per day, cement at $2.00 per barrel, and estimating that a team of three men will mix their own material, and make 70 pieces of 2'x20" tile per day of 10 hours, we may make the following deduction: Each tile will contain 1 67-100 cubic feet of sand at a cost of 4½c; 56 pounds of cement at a cost of 26 6-10c; labor cost will be 9c per tile, making a total cost of 40c for a 2'x20" tile, or a cost of 20c per foot. These figures are very conservative, and I am told by one of the members of your association that the labor cost has been reduced in his yard from 25 to 35 percent. below the estimate given. So it seems safe to figure on a cost basis of 20c per foot for the manufactured product.

The addition of a bell end to make a sewer pipe out of this same tile increases the cost very slightly, and figuring on the same basis 20" bell end 2' pipe can be made for 51c or a trifle over 25½c per lineal foot.

I have been endeavoring during the past few months to collect some data on the subject of cement sewer pipe, and have a large number of inquiries out at this time, from which I hope to gather some interesting infomation in the near future, which will be tabulated and published in the trade papers.

I find in a report by the City Engineer of Richmond, Virginia, that five blocks of 20" cement sewer pipe were laid in that city in 1874. The reports of the Sewerage Department show an expenditure of less than $200.00 for repairs during this period and the same are in first class condition today.

I find also that the city of Milwaukee, Wis., one of the very best sewered cities of the United States, contains fully 50 percent. cement sewer pipe, some of which have been in use twenty years, and have given very good general satisfaction.

On the other hand, I find that attempts were made in the early history of the use of cement to make sewer pipe from natural or hydraulic cement, and the results in these cases were very unsatisfactory except where the pipe were subjected to what is known as a carbonizing process. This carbonizing was accom-

plished by placing the pipe in kilns and curing them by steam and gas.

With Portland cement at the present prices however and the added expense of carbonizing, pipe made of natural cement would practically give the field to Portland cement pipe.

I believe that with proper care this may be developed as one of the very best and most profitable lines of the industry, and I trust that those of you who undertake to manufacture cement tile sewer pipe will give it the greatest care and attention.

When you stop to consider that you can make a 2'x24" pipe of a one to three mixture of Portland cement and sand at a cost of practically 68c or 34c per foot, and that the same size in the vitrified clay sells at $1.00 to $1.25 per foot you will realize that the opportunity for profit in this branch of the industry is certainly great.

Another point of advantage in making your own sewer pipe is the fact that when your stock gets low or is exhausted of certain sizes, you have only to make up for stock those sizes that you are short on, while if you are handling the clay pipe and run out of one size you find it necessary to order a whole car load, and many times you will have on hand a much larger stock of some sizes than you wish to carry.

So much for the subject of cement tile and sewer pipe. I believe you will find it worth your careful investigation.

There have also been many interesting developments in the use of cement on the farm. It has been applied in making fence posts, water-troughs, stable floors and many other improvements which I will not enumerate. All in all we have witnessed a very highly satisfactory growth as well as a very interesting development.

The increase in the production of cement during the past year is certainly enormous. The total production of the mills of this country amounted to 27,000,000 barrels as compared to 23,000,000 the year before, which is an increase of 17.4 percent. Last year I made a statement to you that the 23,000,000 barrels of cement produced in 1904 would be sufficient to make 530,400,000 cubic feet of solid concrete, mixed in the proportion of one to four, or 736,000,000 cubic feet of the average hollow block wall mixed in the same proportion.

I also stated that this would lay up a 12" wall 25' high around the state of Iowa and on every county line. The increase in the production of Portland cement the past year applied in the same manner would add 4' 4" to the height of this wall around the state of Iowa and on every county line.

In the face of this enormous increase in production the storage bins of the Portland cement manufacturers are comparatively empty for this season of the year as it is customary for them to

have their bins filled to overflowing at this time on account of the lack of shipments during the winter months. There has been an unusual demand for shipments during the entire winter season, which has resulted in greatly increased prices over one year ago. So far as I can see this is a result of legitimate demand and supply notwithstanding the fact that we hear many protests about trust prices in cement. The use of cement during the winter months has greatly increased in the past year.

A year ago it was estimated that there was something like 2000 plants in operation in the United States manufacturing concrete blocks. I will not attempt to tell you how many plants there are in operation today, but there is hardly a town in the country but has some kind of a cement block outfit. I have on file in my offices names of 7500 people who are financially interested in this industry. Some plants are very poor excuses, and on the other hand some are very pretentious and successful plants. Many of these plants have increased their usefulness as well as profits by adding the manufacture of new products already mentioned such as brick, tile, sewer pipe and the like.

The conditions prevailing today are on an average much superior to those of a year ago, but at the same time this rapid growth sounds a note of warning, and we must use greater care and caution at every step. It is very essential that the public should understand this subject as thoroughly as possible in order to put a check on unscrupulous manufacturers. The public should know what constitutes the material for making a first class product, and should know when they are getting it.

It occurs to me that the man who does not attain the highest degree of success warranted by the conditions under which he is laboring is as much to be criticized as the man who makes a total failure under favorable conditions.

It is certainly gratifying to know that the United States government has considered the development of this industry of sufficient importance to make very liberal appropriations for the maintenance of an experimental station under the direction of the United States Geological Survey at St. Louis. Mr. Richard L. Humphrey, the honored president of the National association, has charge of the work at St. Louis, and the work he is carrying on will result in much good to all of us who are interested in this business. Sample structures of various forms of concrete construction, including the use of hollow blocks, brick, reinforced work and the like will be erected, and tested for load carrying capacities, fire resistance, etc. These experiments will result in the development of what will be recognized as standard specifications for the manufacture of this material. This work while fostered by the government is being carried on in conjunction with and under the direction and suggestions of many other interested

societies and associations, among them being the American Society for Testing Material, the National Association of Portland Cement Manufacturers, American Society of Engineers, the National Association of Fire Underwriters. And I predict that when this work has been completed we will secure much more favorable insurance rates, more reasonable legislation in respect to building ordinances in our cities, and in general the recommendation of this material which is its due.

I believe this association should adopt a resolution endorsing this work, and requesting an increased appropriation for its continuance, and that every member should make it his business to address his congressman and state senator on the subject, asking their co-operation in securing this appropriation.

Many of you have doubtless received adverse criticisms on your work from architects and builders, and I believe that many of them have been just criticisms. Many of us have found fault with our architect because he would not take readily to this material, but we must remember that the architect is naturally slow to leave the well trodden paths in order to explore what to him is a comparatively unknown field. I say we have been to blame for many of these criticisms, and that they are just, and I only ask any of you to recall to mind the first concrete block building that was put up in your town. If I mistake not the picture that comes to your mind's eye is that of a building that shows no attempt at ornamentation. Every stone of which is exactly the same size and design of rock face. Is it any wonder your architect criticizes the appearance of this building when he can produce almost the same effect with a few rough boards and a little stamped sheet iron. I think the time has now come when you will get away from this idea of a rock face stone, which at its best is but a cheap imitation.

I have stated before and I wish to repeat that a concrete building should be recognized as such, and that this material is good enough, beautiful enough and strong enough to take a classification by itself, and that it should be recognized in every case as concrete. How many of you are making all the designs of stone that your machine or outfit is capable? I dare say not one in ten. Your men will get started on a certain style of stone and then continue it indefinitely. It is certainly a lamentable fact that a material which is so susceptible to the artistic touch and so easily given an ornamental appearance has been so shamefully treated. If you will but combine the wisdom you have already acquired as to manufacture with a little artistic taste you will place this business on a much higher plane.

I wish to touch on this subject of general or standard specifications as I believe there are certain general rules that can be laid down and strictly adhered to which are not yet as well under-

stood as they might be. One of our prominent Portland cement manufacturers has circulated some advertising matter in which he says that "a block well made and poorly cured will be a failure," and that "a block well cured and poorly made will be the same," which is certainly good logic.

At a meeting of the manufacturers of cement block machinery held in Chicago last summer I introduced a resolution looking to the appointment of a committee to draw up standard specifications for the manufacture of concrete blocks. I have been somewhat severely criticised from some quarters for taking this position. I wish to state first that I have no apologies to offer and that my object in so doing was to get the manufacturers of concrete block machinery on to a uniform basis so that their estimates would not be so greatly at variance. For I believe this to be a good straight, legitimate business proposition, not a "get rich quick" scheme as one would be led to believe from reading some of the literature in circulation. And I also firmly believe that the manufacturer of cement block machinery should be more vitally interested in the success of this business or in the success of his customers than any other person.

In connection with the other members of the committee appointed for this purpose I have prepared standard specifications which have been submitted to the association as a progress report. We do not consider that we have reached the millenium by any means, but we have laid down certain principles, certain rules which if followed will insure a safe product. We have aimed to be inside with a good factor of safety in every instance.

These specifications were adopted by the Northwest Cement Product Association in Minneapolis with a few minor changes, and I wish to present them for your consideration here during this meeting, at which time I would like to take up with you more fully the subject of selection of materials and manufacture and curing of the product.

The remaining papers and the proceedings of the business session will be published in the next (May) issue of the Iowa Engineer.

EXHIBITORS AT THE CONVENTION.

J. A. Sodestrom, Sac City, Iowa, one lever cement brick machine.

Cement Machinery Mfg. Co., Burlington, Iowa, represented by C. B. Foster, model cement block machine.

Illinois Gravel Co., Princeton, Ill., represented by L. H. Scott and Wm. Allis, block machine.

Iowa Building Block Machine Co., Waterloo, Iowa, represented by J. L. Shannon and H. L. Green, block machine.

Ideal Concrete Machinery Co., South Bend, Ind., by F. J. Fitzsimmons and O. R. Chestnutwood.

Miracle Pressed Stone Co., Minneapolis, Minn., by O. U. Miracle, Geo. F. Birmingham, A. G. Furbur, block machine, concrete mixer, cement brick machine and many cement working utensils.

Waterloo Concrete Brick and Block Machine, Waterloo, Iowa, represented by T. E. McStay.

Municipal Engineering and Contracting Co., Railway Exchange, Chicago, Ill., by T. M. Meek, model cube concrete mixer.

Peerless Cement Brick Co., Lumber Exchange, Minneapolis, Minn., by L. V. Thayer, cement brick machine.

Lensch Manufacturing Co., Waterloo, Iowa, by F. M. Lensch, and T. O. Axtel, cement shingle machine.

Waterloo Cement Tile Machine Co., La Fayette Bldg., Waterloo, Iowa, by G. W. Baughman and J. H. Stewart, drain tile and sewer pipe machine.

Baldwin and Schales Co., Waterloo, Iowa, by C. L. Baldwin, Polygon mixing machine.

Mammoth Concrete Tile Mould Co., Kimballton, Iowa, by Henninger and Jensen, tile mould.

Anchor Concrete Stone Co., Rock Rapids, Iowa, by Chas. W. Bradley, general manager, block machine.

Iowa Novelty Co., Burlington, Iowa, by Leo Brutus, bronze cement working tools.

Cement Tile Machine Works, Scranton, Iowa, by Allen Glenn and S. G. Kions, drain tile machine.

Stevens Cast Stone Co., Chicago, Ill., by C. W. Stevens and Geo. A. Backrath, artificial stone-casting machine.

Marquette Cement Mfg. Co., Marquette Bldg., Chicago, Ill., by J. W. Dickinson, R. B. Dickinson and A. A. Sheneberger.

Atlas Portland Cement Co., 30 Broad St., New York City, by D. B. Pierson and B. J. Swett.

Chicago Portland Cement Co., Chicago, Ill., by J. W. Woodruff.

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T. J. Johnson, Grundy Center, Ia.
Wm. Valentine, Casey, Ia.
B. F. Gove, Griswold, Ia.
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THE IOWA ENGINEER

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PROCEEDINGS OF THE SECOND ANNUAL CONVENTION OF THE IOWA ASSOCIATION OF CEMENT USERS

(Continued from the March number)

THE CEMENT QUESTION FROM THE FARMER'S STANDPOINT.

H. R. BOOKNAU, *Grinnell, Iowa.*

The first essential to success with anything is to get the ideal pictured in the mind. It is thus with a cement foundation. As I have it pictured, it must be moulded into place without any wooden window or door frames.

Cement is to take the place of stone and brick and, to a large extent, of lumber. Our experience with stone has been unprofitable. Everything we have been able to find has decayed and crumbled to pieces, so why should we try to imitate a stone finish? It is my opinion that it is only a question of time with the cement block. I am well aware of the fact that a great many people are taking out patents on different kinds of cement blocks. Only a year ago last winter, in Chicago, I saw a couple of men who had devised and patented a water tank. They had taken considerable pains to reinforce it with iron. These men were from Ohio. They had come to Chicago to work up a sale for their patent cement water tank. The same day I saw another man from northern Ohio who had made and used for three years with good results, a cement water tank which was six to one moulded without any reinforcement with iron. I myself moulded in a cement watering place in one of my pas-

tures. It cost, all told, $30.00. One of my neighbors just across the line in Marshall county put in one with cement blocks which cost him $90.00, a difference of $60.00. He paid very dearly for what he didn't know, besides, he hasn't got a good job now, nor will it ever be. We have 230,000 farmers in Iowa; if they should all make this same mistake, it would involve the enormous amount of $13,800.00.

In putting in a cement watering place the first step is drainage. The ground on which it is built should be well drained with large tile to remove the ground-water. The surface water will never do any harm. Right here let me say that the importance of drainage should not be overlooked. In building any kind of structure of cement, there is increased weight. The old saying, "You must dig deep to lay a foundation," does not hold good when the ground is well drained from four to six feet deep. You can get a firmer foundation by draining the ground thoroughly and then building on the surface and grading to it. It is only a question of time when the moulded cement house with cement floor and ceilings and partitions, with a cement chimney lined with common drain tile will be a recognized reality. Then we shall have largely averted the danger of burning so many homes from defective flues.

A farmer who isn't using cement in place of stone, brick and, to a large extent, of lumber, isn't up to date. The more I study and the more I think about cement and the various uses to which it can be put the more I can see and realize the economy and durability of it. In a great many buildings a cement floor can be put in for about one-third what a wooden floor would cost.

Now the road is a branch of the farmer's business. I am speaking of cement as viewed from the farmer's standpoint. The road is a part of the farm and it is for the farm, therefore it is a part of the farmer's business to build and maintain it. If the land owners and tax payers of Iowa were solicitous for their best interests, they would this year stop using wood and never use another piece of lumber in connection with road building. After doing what could be done with tile the number of bridges would be reduced about eighty per cent and the culverts would all be unnecessary. Then we could build the rest of cement reinforced with iron. This might seem costly to some, or even extravagant; but it is not. The way we are trying to keep up our roads by driving piling and building wooden bridges is a needless waste. Every farmer who hopes to see his work prosper should learn to use cement in every place possible for several reasons. One is, at the present rate of using lumber the supply cannot last over fifty or seventy-five years at the best. It is only fifty years since we really began to draw

on the timber supply of Wisconsin and Minnesota and it is already about gone. Some conservative estimates have been made that it will last only fifteen or twenty years longer.

As a rule we Iowa farmers are very extravagant and wasteful. It is truly wonderful what loss the farm can stand and yet run. Only a few years ago I built a large barn and put 6 x 12 sills in it. Now I am taking them out and putting in cement so as to make the sill a part of the manger and also a part of the floor. All this will still be cheaper than using wood.

Only last fall I saw several farmers putting wooden floors in corn cribs and corn barns, when at the same time they could have used cement and saved three-fourths of the cost, to say nothing of durability.

Then there is another advantage. Any man can work cement. It is not necessary to have a master workman. At this day and age a man to succeed must be educated along several lines of business, and especially is this true of the farmer. The future development of cement on the farm looks bright to me. The farmers of Iowa can use $20,000,000.00 worth of cement annually for some time to come, and it would be a good paying investment. And good results always follow good investments.

Every bit of hay and grain that is fed to stock of any kind should be fed on a cement floor or in a cement manger. There are those who think it makes no difference with a hog, whether it is fed in a mud hole or on a cement floor; but it is a mistake. It pays to feed and water the pig on a cement floor and out of a cement trough.

I have read of some very expensive plans for putting in an outlet for a tile drain with brick or with stone; but if the first few pieces are laid in cement and well covered with cement three or four inches deep, it will be a permanent job.

But this is not all of the uses that cement can be put to on the farm. We can make tubs to salt our meat in and cement refrigerators in which to keep it.

DISCUSSION.

Question—I would like to ask if the speaker used this cement floor in the corn crib for six years and if in that time he had any mouldy corn.

Mr. Booknau—No. It has been a great deal better than a wooden floor.

Question—I would like to ask him how he made his stock tank.

Mr. Booknau—My watering place is down in a slough where I needed to tile-drain the ground. I dug up the slough far enough to get into the ground five or six feet deep; then I stopped and laid in the drain tile and raised the ground a foot

and a half over that tile. After I had dug out a place to drain the water into I built the cement work right down in an open ditch four feet deep. It was a rather muddy place, but you know you can tile out a muddy hole no matter what it is. After I got the ground leveled down I put in my cement mortar 10" or 12" thick and about 3 1-2 feet wide. Then I set my mould inside. Outside, the ground was the form for it. The tank when it was finished was 16 feet long and 3 1-2 feet wide.

Now I spoke of the other tank in my paper not to find fault with the cement block, but because of the mistake he made in paying so much. In order to be certain I made it my business to go and see the one that was made of cement blocks. I could not think it possible that there was that much difference in cost. Figuring the cost and the hauling of the sand it came to $4.50 a yard and the tank actually cost me only $30.00. It could be made cheaper now. Some of my neighbors wanted a tank that was a good deal smaller than mine. They didn't require such a large one and it would not cost over $15.00.

Mr. Coutts—Mr. Booknau told me some time ago about two posts he made out of cement. I was in hopes he would include that in his paper today. I would like to have him state to this convention how he made those posts, and what they cost.

Mr. Booknau—Now, Mr. President, I wasn't going to say anything about those posts for there are a number of Grinnell men who have watched and criticised me for the last twenty-five years. I didn't know anything about a cement post or anything of the kind. What little I did know about cement I got from this gentleman, our president. (Much applause.)

Well, I made those posts and expect them to stay for several years. I find there are a good many things on the farm that a man must make, he cannot buy them. One of these things is a wire stretcher. You may think this strange when there are so many different kinds, but the principal thing with the wire fence on a farm is the tension of the wire. I have tried a dozen different wire stretchers and finally came to the conclusion that there was no wire stretcher made that was worth using. I realizd I could not get a stretcher, so went to work to make one. I tried different methods by way of experiment and finally learned I could make one by wrapping it five or six times. I have a good deal of fence to keep up on an 800 acre farm and if a person doesn't think it is a hard job to run and keep up 800 acres then let him try it. I set to work to make a corner post. I got my load of sand and dug a hole in the ground three feet in diameter and 5 1-2 feet deep; mixed up the mortar in my wagon and drove down to the corner of my farm with the sand and cement in the wagon. After I got two feet of cement and sand in the bottom of the hole I set in five bars of iron, one to

each corner. These bars of iron were 1 1-2" wide and 5-16" thick. I put a 1 1-2" gas pipe in the center, built it up to the surface and then put a barrel around it for the form. When it was done I had used 11 sacks of cement, I think, and 27 sacks of sand and it weighed 4140 pounds. The post stood 4 1-2 feet out of the ground. It seems costly I will admit, but it is a cheap post because I studied the fence as I study all the various interests of my farm.

Now when I got my fence post made I didn't touch it for two or three weeks. I was not afraid anyone would carry it away or anything of that kind; but after it had been there three or four weeks I drew up my wire. If you are a close observer of little things you will notice that a great many farms have their posts 10 and 12 feet apart and most of them have them 16 feet apart. That fence post cost $10.50, but if it had cost $25.00 it would have saved me money, for in that mile of fence I saved 160 posts. At 22 cents each these would cost more than two posts I put in.

Question—What mixture did you use for your water tank?

Mr. Booknau—4 to 1 for the water tank.

TESTS OF CONCRETE BLOCKS.

BY A. MARSTON AND M. J. REINHART.

One year ago I had the pleasure of addressing this convention on the subject of "Tests of Building Materials" in general. Today we wish to present the results of some actual tests of cement blocks.

Before proceeding with the results of these tests, however, I wish to call attention to our bulletin on "Tests of Cement" just published. It is No. 1 of Vol. III of the bulletins of the Engineering Experiment Station of the college. A number of these bulletins have been placed upon the table and you are invited to help yourselves. These and the other bulletins of the Engineering Experiment Station can be obtained free by writing to the Director of the Station.

In the development of any new industry such as the manufacture of cement blocks, tests are especially important, because of the lack of skill in manufacture, which can be obtained only by long experience. In the early history of the manufacture of cement blocks in this state many mistakes have been made, I firmly believe. Too little cement has been used in the blocks. In some cases poor cement has been used; in many cases poor gravel has caused imperfections in the product; the curing of the blocks has not been carried out as it should be; and altogether too little attention has been paid to making the blocks impermeable to water.

In fact, expert skill is required in cement block manufacture, just as in any other industry, to secure good results. It was a mistake to believe that in the use of cement "Tom, Dick and Harry" were qualified to do good work.

That this statement as to the cement block industry in Iowa is correct is shown by the great improvement in the quality of the blocks as indicated by the tests which we have been making during the last two or three years. When the industry was first started we obtained blocks from different manufacturers and made a set of tests, which I believe were the first of any moment whose results were published in this country. The results of this first series of tests are shown in Table No. 1.

From this table it will be seen that the crushing strength of the blocks ranged from 28.5 to 48.8 tons per square foot, and that the blocks were disintegrated by freezing and thawing from 3 to 12 times.

Since making the first series of tests we have been making occasional tests of cement blocks sent in to us by the manufacturers of the state, and from the results Table No. 2 has been prepared.

From this table it will be seen that the crushing strength of the blocks ranged from 21 to 113 tons per square foot. Throwing out blocks tested at very early ages, the minimum strength was 43 tons per square foot, which was near the maximum of the first series of blocks tested.

At the same time that these tests of strength shown in Table No. 2 were made we were carrying on freezing and thawing tests also. Four samples of Estherville Building Stone cement blocks were tested, and also four samples of Munn Building blocks, manufactured in Ames. The proportions of materials used in the Munn blocks were 1 cement to 4 of gravel. In the case of the Estherville blocks there was no apparent loss until the end of 65 freezings, when one of the samples disintegrated. At the end of 75 freezings another of the samples had lost 10 per cent of its weight. This sample completely disintegrated at the end of 95 freezings, as did the third sample. The fourth sample required 100 freezings to destroy it.
until the end of 50 freezings, when one sample had lost 2.8 per cent and another 11.8 per cent of its weight. The first two blocks to be destroyed failed at the end of 65 freezings and the third at the end of 70 freezings. The fourth block failed at the end of 90 freezings.

When we compare these results with those of the early tests, in which the blocks failed at the end of from 3 to 12 freezings, great improvement is to be noted.

CIVIL ENGINEERING DEPARTMENT, IOWA STATE COLLEGE, JAN., 1904.

SPECIMEN	PROPORTIONS	APPROX. AGE Mo.	CITY	NUMBER	SIZE	CRUSHING TEST LARGE SHAPES TONS PER SQ.FT.	CRUSHING TEST LARGE SHAPES #□"	CRUSHING TEST 2 INCH CUBES #□"	TRANSVERSE TEST TOTAL LOAD	TRANSVERSE TEST Modulus of Rupture	ABSORPTION TEST % 15 m.	% 30 m.	% 1 Hr.	% 2 hrs	% 6 hrs	% 1 da.	% 2 da.	% 3 da.	% 4 da.	FREEZING & THAWING ORIG. WT.	WEIGHT AFTER 3 da.	6 da.	9 da.	12 da.
Cement Sand Brick	1-8		Waterloo	1	4.06"x2.25"			660	# 850	#□" 373	8.1	9.1	9.6	9.8	9.9	10.1	11.5	12.1	12.1	gr. 339	gr. 345	gr. 200	153	*
" " "	1-8		"	2	4.00"x2.25"			727	835	371	5.1	6.1	6.8	7.0	7.2	7.4	7.7	7.7	7.7	329	332	*		
" " "	1-5		"	3	4.05"x2.27"			590	930	401	2.2	3.6	4.1	4.6	4.8	4.9	5.0	5.5	5.5	356.5	35.6	26.3	*	
" " "	1-5		"	4	4.09"x2.25"			570	710	309	4.0	4.6	4.6	4.6	4.6	4.6	4.9	4.9	4.9	330	330	238	*	
" " "	1-4		"	5	4.05"x2.25"			1809	790	347	.6	3.3	3.6	3.6	3.6	3.8	3.9	4.4	4.6	365	380	31.4	263	*
" " "	1-4		"	6	4.13"x2.30"			1084	650	267	2.4	2.8	3.4	3.7	3.7	4.0	4.3	4.3	4.7	36.8	36.4	19.8	*	
Concrete Blocks	1-5	4.5	"	1b	10"x9" x2'-6¼"	+48.0	880	974	5940	426	5.5	7.1	7.5	7.8	8.1	8.5	9.5	9.5	9.5	379	373	34.0	210	95
" "	1-5	"	"	2b	10"x9" x2'-6"	28.5	570	1145	4050	328	2.7	2.9	3.0	3.1	3.4	4.7	4.7	4.8	4.8	404.5	292	292	202	*
" "	1-5	"	"	3b	10"x9" x2'-8"	+48.0	939	859	3330	260	7.8	8.3	8.4	8.7	8.7	9.0	9.2	9.8	9.8	35.9	30.3	17.3	*	
" "	1-5	"	"	4b	10"x9" x2'-6"	+48.0	931	337	3060	23.5	3.0	3.3	3.5	3.7	4.1	4.6	4.7	4.8	4.8	37.9	37.7	21.3	195	*
" "	1-4	1.7	Sac City	1a	8"x9" x1'-3¼"			1417	4300	196	3.2	3.7	4.6	4.9	5.4	5.4	6.2	6.2	6.6	40.1	39.3	33.5	*	
" "	1-4	"	" "	2a	10"x9" x1'-3¾"			967	4600	158	2.1	3.2	3.5	3.7	4.1	4.3	5.2	5.4	5.4	351.5	30.7	30.0	*	
" "	1-4	"	" "	3a	8"x9" x1'-4"	45.8	899	800			7.5	7.8	8.0	8.1	8.5	9.0	9.9	9.9	9.9	32.4	27.2	26.4	*	
" "	1-4	"	" "	4a	8"x9" x1'-3¾"	+48.8	963	815			4.5	4.6	4.8	4.8	4.9	5.5	6.0	6.3	6.3	39.0	29.5	28.0	23.0	*
" "	1-4	"	" "	5a	8"x9" x1'-3¾"	41.9	841	1236			3.6	4.1	4.1	4.1	4.2	4.6	5.2	5.4	5.4	42.7	39.6	38.2	35.2	15.7
" "		6	Webster City	1c	10"x9" x2'-7¾"	45.0	822	1430	1365	105	5.5	5.8	5.8	6.1	6.3	6.8	6.7	6.9	6.9	37.9	*			
" "		"	" "	2c	8"x9" x2'-7¾"	35.8	683	1270	1580	160	6.0	6.7	7.0	7.4	7.9	8.1	8.4	8.6	8.6	30.9	26.8	13.8	*	
" "		"	" "	3c	10"x9" x1'-3¾"			1250	3630	111	10.3	10.5	11.0	11.4	11.6	12.3	12.3	12.5	12.5	31.1	28.7	16.2	*	
" "		"	" "	4c	8"x9" x1'-3¾"			990	7440	330	7.4	8.2	8.2	8.5	8.7	8.7	9.0	9.1	9.3	34.6	33.4	18.2	*	
" "		"	" "	5c	8"x9" x1'-3¾"	48.7	950	930			6.1	6.3	6.3	6.3	6.3	6.4	6.9	7.0	7.0	40.0	34.9	30.2	*	
" "		"	" "	6c	10"x9" x1'-4"	40.5	778	806			7.6	7.8	8.3	8.5	9.1	9.3	8.6	9.6	9.6	29.6	27.1	17.2	*	
Sand Lime Brick																				WEIGHT AFTER 4 da.	8 da.	16 da.	22 da.	29 da.
				1	2¼"x4" x 8¾"			2097	1600	635								11.0		gr. 402	gr. 31.9	gr. 25.2	gr. 19.1	gr. *
								3210										10.9		420.5	37.7	28.4	21.8	12.5

+ Failed to crush at full power of machine.

½ of (1b - 2b - 3b - 4b - 1c - 2c) was crushed for the Crushing Test. * Entirely Disintegrated.

TABLE 2.

TESTS OF CONCRETE BLOCKS

SPECIMEN	tions	E ximate	CITY	SIZE	CRUSHING TESTS	TRANSVERSE TESTS	ULUS of URE

TABLE 2.

TESTS OF CONCRETE BLOCKS

	tions	E ximate			CRUSHING TESTS	TRANSVERSE TESTS	LUS f URE

TABLE NO. 3.

TESTS OF CONCRETE BLOCKS, JANUARY, 1906.

These specimens were all one piece blocks, proportions 1 to 4.

Approx. Age.	City	Size	Crushing Tests: Pounds per sq. in.	Crushing Tests: Tons per sq. ft.	Transverse Tests: Distance between Supports	Transverse Tests: Ultimate Load	Modulus of Rupture Pounds per sq. in.
4 mo.	Neola, Iowa	8"x8"x24"	1450	68.5	18"	2100 lbs	178
4 mo.	Neola, Iowa	8"x8"x24"	1052	49.	18"	2300 lbs	191
5 mo.	Neola, Iowa	8"x8"x24"	1255	62.	18"	5650 lbs	466
5 mo.	Neola, Iowa	8"x8"x24"	....	....	18"	4100 lbs	315
3 mo.	Ames, Iowa	8"x9"x24"	1940	74.	18"	4490 lbs	250
9 mo.	Ames, Iowa	8"x12"x24"	1068	60.	18"	6750 lbs	406
16 mo.	Ames, Iowa	8"x9"x24"	....	....	16"	5370 lbs	285
8 mo.	Centerville, Ia	8"x9"x24"	....	....	18"	2650 lbs	150

Some additional strength tests, made very recently, are shown in Table No. 3, in which it will be seen that the high structural strength shown by the later tests is being maintained.

The moral to be drawn from these tests is not to skimp in the cement, and to use the utmost skill and care in every step in the process of manufacture.

TESTING THE WATER PROOF QUALITIES OF CONCRETE BLOCKS.

A few years ago when concrete blocks were first put upon the market as a building material, the question of strength was perhaps the first to arise among the builders and the public. Were the blocks strong enough to resist the stress in a wall? To convince the public many tests have since been made, numerous specimen tests such as you have just seen before you have been carried out. Even more important than this have been the structural tests, the large buildings which have been built of concrete blocks, that are still standing, and which we expect to stand for years to come. It is true that the stress in a block wall due to its own height is only one pound per square inch per foot of height. In a wall 200 feet high the stress in the lower courses due to the weight of the wall alone would be only 200 pounds per square inch, which with the ordinary block would give us a very large factor of safety. Thus we see that the question of strength is not such a serious one, but there is another more serious fault which we know hinders the use of concrete blocks in many cases,—that of water penetration, or permeability of the blocks.

It has long been known that water will permeate ordinary masonry, and that plastering directly upon stone or brick walls had to be avoided. This is also a great draw-back in concrete block construction, and at the present time it is generally considered necessary for the wall to be furred and lathed before plastering.

Builders have learned that even then block construction, as regards cost, compares quite favorably with frame, and it is cheaper than ordinary brick, and greatly under cut stone; but if it were possible to plaster directly on the inside surface the use of concrete blocks would certainly be greatly increased.

To avoid this fault of the ordinary concrete block many methods have been tried to prevent this excessive water penetration. The air space in the wall was the first perhaps, and the blocks with the single core, the double core, and the two piece blocks have been tried. The methods of mixing, the damp, the wet, and liquid mixtures; and we have the hand tamped, the high pressure, and the poured blocks. To make the blocks less porous, rich mixtures have been used, but this is an expensive means; properly graded materials decrease the porosity but we cannot rely wholly on this. Again, the use of a facing on the block, the impervious partitions, the water proof compounds mixed in the cement, the use of lime in the mortar, the application of a wash or solution to the wall after it has been erected, and perhaps numerous other methods, all have particular advantages claimed for them, and all have their places in overcoming this great objection to concrete blocks.

In order to test these various methods of making the blocks or walls impervious, and to determine the relative permeability of concrete blocks as compared with other materials of construction, we have endeavored to devise a test which would approach as nearly as possible to the actual weather conditions to which blocks and other materials in a wall are subjected.

Before going further I wish to make clear a distinction between the porosity and permeability of a material. By porosity is meant the total amount of voids, but by permeability is meant the rate at which water will permeate or penetrate the material under a given pressure. A material might be very porous and yet water penetrate it very slowly. Thus permeability depends upon the size of the open spaces or voids as well as upon the total amount. Therefore any method of simply determining the porosity or amount of voids in a block would come far from giving us its relative value for use in a wall.

The views Figs. 1 and 2 show a test of a block in operation. The block is placed in the box, face out, just as it would be in a wall. The two sides of the opening, the upper and the left, are adjustable and can be fitted to any ordinary block. Ex-

FIG. 1—Front View of Test

FIG. 2—Rear View of Test

tending around the block is a place for a mortar joint, 3-8" thick by 1" wide. This was filled with good Portland cement mortar and allowed to set for 15 hours. All the cracks at the corners and edges of the box, and all openings on the front side were closed with plaster of Paris to make it impossible for water to get to the back of the block any way except by going through the face.

The face of the block was placed 5" from the spray pipe, which is a 1" pipe arranged with openings 2" apart and 1-32" in diameter. By means of the valve it is possible to get any desired pressue in the pipe, which can be measured by the pressure gauge. In this particular test the spray was applied for 6 hours at a pressure of 2 pounds per square inch. At the end of three hours the water had just penetrated the 8" of solid concrete. In 6 hours the entire block was wet, and upon weighing the block it was found that it had gained a little less than 6 per cent in weight.

This was a block of 1 to 4 mixture, single air space, size 8" x 8" x 24", was 5 months old, and when tested later in the transverse machine showed a modulus of rupture of over 300 pounds per square inch.

Another block with the double air space was tested. In 3 hours it was wet about half way through and at the end of 6 hours the top third behind the cores was still dry. This was a 1-4 block, size 8" x 9" x 24". The block was 16 months old and showed a modulus of rupture of about 150 lbs. It gained a little more than 6 per cent in weight.

We expect to continue these tests of the waterproof qualities of blocks, and later will make the same tests on other materials, such as brick and stone, by taking blocks about the same size from old walls and testing them in identically the same way.

Here there is also a chance to test the various washes put upon the market and sold to builders to make their wall impervious. We expect to experiment along this line, to try a cement wash and in this and other ways see what can be done to better the waterproof qualities of concrete blocks, and thus bring the block industry into better favor with the public.

DISCUSSION.

Mr. Miracle—I would like to ask Mr. Reinhart if he doesn't think it would be a better test to lay up a little section of wall, for in many cases I have found where buildings were wet the moisture had come through the joints.

Mr. Reinhart—I think, Mr. Miracle, in this case we have a joint practically the same as it would be in the ordinary wall, and it has a chance to wet through there as it does in any wall

The joint is 3-8″ thick of ordinary mortar as it would be in the wall after it was pointed up.

WATERPROOFING OF CEMENT SURFACES.

J. B. MARSH, *Des Moines, Iowa.*

During an experience of over five years in the building of concrete structures we have made nearly a mile and a quarter of concrete steel bridges. In most of these it was necessary to waterproof a part of the structure to prevent the entrance of water and the subsequent discoloration of the concrete. I refer to the tops of arches and about a foot of the spandrel walls.

The first bridge of importance, one of seven 72-foot spans at Waterloo, Iowa, was waterproofed with Barrett Bros. No. 6 Pavement Filler, which seemed to answer the purpose for which it was used. The Topeka bridge, built last season, was waterproofed with a heavy coat of Genuine Asphalt Filler made by the American Asphaltum and Rubber Company of Chicago. The Trinidad bridge, and the Cedar Rapids bridge built last year and the Kankakee bridge built two years ago were waterproofed with a cement grout composed of one part cement and one part sand.

The waterproofing of the Waterloo and Topeka bridges is such as will decay and lose its adhesiveness in time, as shown by its condition in the old part of the Sixth Avenue bridge at Des Moines. Last season when the additional spans were built at the north end it was discovered that the waterproofing, which was an asphalt compound, could be pulled off in long strips. Ideally perfect waterproofing qualities could hardly be claimed for such material.

Furthermore, on those bridges where a cement grout plaster was used, the waterproof condition will last, if the material in the arches is not waterproof, only so long as the plaster does not check or crack. The richer quality of this surfacing and its having been applied after the other was set produce a joint, as is the case in some cement walks.

Last summer we constructed a reservoir, designed by W. D. Lovel, consulting engineer, of Minneapolis, for Charles City, Iowa. The specifications called for a 1:3:5 mixture, which we do not believe impervious to water, and a coat of plaster one-half inch thick composed of one part cement and one part sand, to be placed after the walls had set. As soon as it was completed, and filled with water, leaks were discovered. However, it leaked only in spots. The breaking down of our mixer prevented continuous running and a week old joint had to be made, and for some reason the 1:1 plaster did not fulfil its mission by preventing the leak.

To overcome the trouble we used a waterproofing material known as Elaterite Cement Paint, manufactured by the Elaterite Paint and Manufacturing Company of Des Moines, Iowa, one coat of which absolutely stopped all leakage. It is our opinion that this paint fulfils the requirements for a waterproofing material. The arches waterproofed by us with other materials have never leaked, but the waterproofing was used on what we believe to be waterproof surfaces, while in the case of the reservoir it was absolutely known that a waterproof condition was produced only after the application of the Elaterite compound.

A brief discussion of this product may be of passing interest. The base of the paint is a pure carbon ore, elaterite, called also "Mineral Rubber" because of its extreme elastic properties, found in Colorado and Utah. Because of its insolubility its extensive commercial use was prevented until recently when a process was discovered whereby its treatment was made possible.

The pigment ore is not ground as is usual in preparing paint pigments but by this recently discovered special process it is converted into a liquid that enters into so thorough combination with the carrying oils that, no matter how thin a coat is used, so long as every part is covered, a waterproof surface is obtained.

The manufactured paint of this ore is impervious to water. Brick, tissue paper, etc., painted with it are shown to be entirely protected against the entrance of water. It is almost or practically as adhesive as glue and will stick to any kind of a surface, never becoming brittle and cracking or peeling. It is non-combustible, heat only making it tougher and more adhesive.

Elaterite is also manufactured into a gum which for waterproofing bridges and other level surfaces can be used as advantageously as the paint. Because this gum does not become hard and brittle and will not crack from vibrations of trains it is very desirable for bridges along elevated railroad tracks. Railroad companies have recognized this fact and are using it in preference to a compound of tar used heretofore. It is also used to calk seams in sea-going vessels.

It is our belief, borne out by experience, that the finished (not troweled) surface of an honest 1:2:4 mixture placed very wet is impervious to water, hence needs no material to make it waterproof. It is a hard thing, however, to so convince the skeptical and suspicious buyer. Concrete girder bridges which we have built that are not waterproofed but which turn absolutely all water, show this most forcibly. These girders are composed of 1:2:4 mixture placed very wet.

If a waterproof material is needed it should meet the following conditions to be thoroughly reliable:

First,—It must be absolutely impervious to water.

Second,—It must have adhesive properties, securing and maintaining a firm hold upon the surface.

Third,—It must not be affected by the action of water, even if acid or alkaline.

Fourth,—It must not disintegrate under the action of air or water and it must completely shut out these disintegrating agencies from the surface on which it is applied.

And Fifth,—It must be sufficiently elastic to meet the extremes of expansion and contraction, caused by changes in weather conditions, without cracking, breaking or peeling.

CEMENT SIDEWALKS.

T. H. Unger, *Coon Rapids, Iowa.*

Mr. President:—

In presenting this paper before the convention, I have outlined in a general way, several topics that should be considered before the main subject is discussed.

1st. Contracting.—As most cement work requires a rigid contract, we should be just as particular in getting value received as the man is who gets the work done.

2nd. "Honesty is the best policy."

Cement work is one of the things in which people have been badly faked. To use an old expression, "You can fool a part of the people all of the time, and you can fool all of the people a part of the time, but you cannot fool all of the people all of the time." Usually in your employ you will have at least one man who will get the idea that there is money in the business. He starts out the next season with the intention of making money.

He has counted all the profits of the year before, but has not taken into consideration any losses that may have occurred. Consequently on meeting with some loss, he slights his work, and the result is of course apparent. This puts an obstacle in the way of the man who does good work; for the people soon lose confidence, and think cement work a failure.

There is no reason why cement work of all kinds, if properly and honestly done, should not last the lifetime of an average man.

In treating the subject "Cement Sidewalks," I will endeavor to give my plans and ideas for the laying of walks, where varying conditions are met. Some think that a walk cannot be laid without first constructing a gravel or cinder bed. This is a mistake. All that is needed is just enough gravel and sand to level the bed. A cement walk can be laid on sod, cut in 4 foot squares and will last a lifetime.

In putting down a walk where there is a retaining wall and also a curb, you have something that will hold water like a tight vessel. During late fall rains water runs down the bank and behind the wall. It settles under the walk, and, the heavier the bed of gravel or cinders on which the walk is laid, especially if in a clay soil, the more water will be held. The consequences on freezing are a broken up sidewalk. It would have broken had it been made of cast iron. In laying a cement walk adjoining a cement or stone wall, a piece of paper should be placed between the wall and the walk, so that when the walk rises, it will not adhere to the wall. In such a location it would be best to spend the same amount of money in putting in drain tile in place of the gravel and cinders.

Where a walk is laid on the level, put the worth of the fill in the material that goes into the walk, and I will guarantee much better results. In putting down walk, I consider four inches of concrete thick enough. In regard to the top dressing, I would rather have a layer one-fourth inch thick, well plastered on to the concrete, than to have more, because it will then all set together, and will not crack loose. All concrete should be made strong enough to become a solid stone of itself, and all you want is just enough to dress it up, and make a neat job.

For city crossings, cement beats all other materials, both in cheapness and durability. We are putting them down in our city six inches thick, and four feet wide at the ends, sloping them a little at the sides. I will say for the benefit of some cement users, who have not pushed this kind of work, that they can be put in for 20 cents per square foot, where gravel costs $1.00 per yard on the ground. Labor can be secured at $2.00 per day, and cement $2.00 per barrel, and the work guaranteed for five years. If you understand your business, there need be no fear that it will ever make you any further trouble.

There is one more subject that I wish to touch upon, and that is a "Cheap John" contractor, who will tell you that he can put down just as good a walk for 7 cents per foot as the other fellow is putting in for ten cents.

Now, I do not think we have any of that kind present at this meeting, for they seldom attend conventions; but if you want to keep up your reputation and your bank account, you must keep up your prices, for there are none of us who can afford to work for nothing.

DISCUSSION.

Question—I would like to ask the gentleman when he puts in a curb if he puts it in separately or whether it is put on the outside of the sidewalk. Some connect the surface on the side-

walk and some put the curb in separately and the sidewalk afterwards. In some cases they put the forms up and then the sidewalk is filled in between the curb.

Mr. Unger—In all cases where I put in a curb, I put it in first and then lay the walk afterwards and let it project over the curb; frost heaving under the walk will loosen it over the curb and won't split your walk. It has got to come up when you get water under the walk. I think a walk looks a little better without a seam.

Speaker's Name Unknown—We put a footing on our curbs so that it will not push out even if the walks rises over it. Put your walk flat on top of the curb and it will rise up in winter time about one-half inch. Even this does no harm, for it will go back down.

Mr. Unger—I have never seen a walk crack. The idea I have is that the walk looks better without that seam than it does with it.

Mr. W. D. Faus—My objection to that way of building a curb is it leaves a seam right at the edge of your walk for the water to settle in between the walk and the curb, while if your walk extends over the top of the curb it drains every bit of water to the gutter.

Mr. Metzgar—I have had some experience in all lines of flat work and when I first started out I made curbs and walks independent; but for years I have practiced the plan of covering the curb with the walk and in such construction realize as well as you that the curb becomes a part of and a support to the walk. You will find that the box curbing gives the best satisfaction.

Mr. R. L. Humphrey—*Members of the Iowa Association of Cement Users*: Your President this morning asked me if I would not say a word to you. I told him yes, because I could talk cement, as I had been in the business a great many years and it was always on tap. A great many points have been raised this morning that I would like to discuss, especially the numerous points that have been brought up about sidewalks, and I confess I differ radically with a great many speakers that have given their views on the subject.

What I want to say to you this morning is along a broader line than that, thinking that perhaps the ideas I may give you will do you some good. I have attended a great many conventions and I have heard expressed the views of thousands that have attended them, and I have been greatly benefited by their experiences. You have heard people say that cement can be used by anyone and the first point I want to emphasize in my remarks is the contrary opinion—cement *cannot be used by any one*. Of all the building materials that we have it is the one

material that requires skill and knowledge of its properties in order to get good results and many of the failures that you have to stand for financially can be attributed to the fact that you did not know how to use that material properly. You are too prone to charge failures up to the cement.

Now cement has been made in this country since '76 and I think we have a pretty good brand of material. We have driven out our foreign competition and are competing successfully in foreign fields which in itself demonstrates the quality. Of course no one manufactures an absolutely perfect article and at times the material may not be quite up to the standard but even the poorest material that is manufactured is a good material if you know how to use it.

Among some of the points that come up is the selection of materials that are to be used with your cement and therein in many cases is the whole jist of the matter. I am very familiar with the materials that are found in the East. I have been surprised to read articles in technical papers by engineers in eastern and southern parts of this country of the failures they have with the materials and I could not exactly understand it; but the past two years I have made it a business to become familiar with the materials that are available in all parts of the country and I can now understand exactly why these failures occur.

We see articles in the papers and we hear people talk about clay and loam not being detrimental up to 12 or 15 percent and to the one who understands what these terms mean it is all right: but let us put ourselves in the position of the cement user who is not versed in the matter and we find that he thinks he must take ordinary fine clay and add it to the sand and thereby dilute the product. As a result you get worse failures from a proposition of that kind than from any other cause. Now your sand has got to be clean and by that we mean free from foreign material like vegetable mold and any substance that is going to hurt the bond, but it doesn't mean that the fine material such as you have in sand or that a clay is going to hurt it; but it is going to benefit it, and the prime object in a mixture is to get the material so proportioned that you have reduced your voids to a minimum. Again I say that you have got to have your material graded from the coarse down to the finest particles and the more of those voids that are filled with finer particles the further will your cement go. Professor Marston has given us some interesting points this morning showing what he has done in this field in developing the strength of the block.

On the question of the strength of the material. You are in competition with brick, and with natural stone and when you consider that this natural material has taken hundreds of years to form you cannot expect to get the same strength in a material

which is formed under the same conditions in the course of a month or, as some people us it, two or three weeks. As we saw in that table of Professor Marston's the concrete after a period of five months will hold 1900 pounds. The poorest kind of a brick will withstand considerable over 6000 pounds per inch and when you get into the granites you have 2200 and 2400 and sometimes as high as 30,000 pounds per square inch.

I know lots of you feel that these criticisms we give you are going to hurt you. You have got to learn your faults and they have got to be put right home to you. That is one of the chief advantages of attending these conventions, to get the facts put before you so that you will get to thinking and in thinking you will solve the difficulty.

Now the question of porosity is important. The block that is dense keeps the water out and certainly that is one of the objects in constructing a building—to shield from the elements. Some of you have built houses in which the first heavy rain makes the wall paper come off and you have corrected the fault. You have done so by filling your voids thoroughly and keeping enough water in there so that the cement, which depends on the water; crystallizes. It is essential to have the water well put on the block after it is made because the process of crystallization is slow and requires time.

You will see from Professor Marston's tests that the older the block is the stronger it is. If you deprive it of water you can prevent its gathering any strength whatever. Now I think one of the troubles you are having is due to the fact that you make up the block today and then expect to put it into the work tomorrow. You will have to rapidly get into a condition where you carry these blocks on hand and where you get them cured sufficiently to acquire the strength that is necessary in the building. A two story house does not require any great amount of strength to sustain the wall but let us take a case where they build a wall twenty-five feet high that is obliged to carry a girder and a lean-to roof. The contractor who had the walls to build started his work in November the weather being exceedingly cold. He did not have more than thirty days before he was expected to put the block in the wall and the block would almost crumble in your hands. He had guaranteed to carry that 50 foot girder 25 feet high with a lean-to roof on the other side. Do not rush in and guarantee things you cannot perform because you will lose in the end. You need to study your product, know and try to remedy its weaknesses and turn out the best block that is possible.

Another point comes up for those who go into the block business for the first time. They make an estimate of what they can sell those blocks for; probably they have been misled by certain statements when they purchased their machines or have

gotten their ideas from other sources. After they have been operating their machine for awhile they find they can not make good, in other words, the block is costing a good deal more than they are getting for it. In order to still continue in business they raise the price. This higher price they will not be able to get readily so they attempt to meet the conditions by decreasing the cement used and therefore reduce the quality of the product. Now that is one of the greatest faults you could think of. What you want to do is to study the natural materials you have in the shape of sand and gravel, find out the proportions to be used and don't use arbitrarily a 1 to 3 or 1 to 4 mixture simply because you understand somebody else does. No materials are exactly alike. They require different handling, different treatment, and you should study your material if you want to get good results.

I have not intended to say as much as I have. In conclusion I will say that the man who knows a great deal about cement gets the greatest amount of good out of these conventions: the man who doesn't know anything doesn't get much. That may seem a strange proposition to you. You must get your own experience, then you can come here and have someone else tell you what the causes of your failures are. You must try them for yourself and then come to these conventions and tell your troubles and someone will get up and tell you the reasons for them. This is especially essential to success in the block business for nearly every one must make a failure before he succeeds.

I think the work that is being done in Iowa by everyone who is using cement is extremely gratifying and it is a revelation to me to be with you and to see the varied forms in which cement is being used in the state. I certainly think you will progress, especially if you attend these conventions and take part in them.

I thank you gentlemen, for listening to me and thank you, Mr. Coutts, for calling on me.

AFTERNOON SESSION, FRIDAY, FEB. 9th.

FACTORY ARRANGEMENT AND EQUIPMENT.

WM. R. DE VRIES, IDA GROVE, IOWA.

The factory should be located on the railroad or a sidetrack, as it is cheaper to haul sand from the pit to the plant, than finished blocks from the plant to the railroad or, to jobs around town. Breakage is also less and a factory located in town is better advertised.

Buildings should be erected of blocks, with the exterior as pleasing as possible. A building 50x100 feet gives ample room for a plant of two hundred blocks capacity per day.

Machines and mixer are best located in such a manner that

the concrete, after being delivered from the mixer, need not be rehandled but when dumped on a concrete floor, can be directly shoveled into the block machine. Concrete floors should also be provided under and around the machine, also plenty of light where machine stands.

Have tracks through the building and outside yards and provide turn-tables at convenient places. 12 pound T-rails spiked to 2x4's or light half cedar posts are of sufficient weight. However, a good and cheap track can be made of 2x4's with buggy tire iron for the top. Make these tracks in 16′ sections, in order that they may be easily moved around the yards, when piles of blocks need to be extended temporarily.

While we never have used double-decked, all steel cars for curing and transferring, we think they would be a great help, as the handling of blocks is a very important item and should be made as easy as possible. Any hard labor saved in this way will amply repay in the larger amount of blocks that can be made with the same number of men.

We use for our green blocks racks, made of 2x4's, 24″ on centers and about 12″ high. They are from 12 to 18′ long and portable and can be placed in the building where most convenient. They should, of course, be as close to the machines as possible.

A space in the building 20′x70′ is sufficient for curing and will hold more than one week's work, setting the blocks on end. The first work in the morning always begins with removing to the outer yards one day's work of the oldest blocks, which probably have been sprinkled and cured for a week.

Provide the sprinkling place with a bed of sand about 10″ deep and keep this part of the house dark allowing no sunlight to play on the green blocks.

Hydrants should be placed conveniently in the building; two hydrants ought to be enough for the size of building mentioned.

An automatic sprinkling device is an ideal arrangement, as the sprinkler can be turned on and do its work, while the men are busy elsewhere and thus no extra man is needed.

For handling blocks we use block-lifters, which can be easily and cheaply made of pieces of hardwood about 2¼″ thick of a size, which readily slips into the hollow space of the block and through which is bored a hole longitudinally and a gas pipe inserted.

For measuring sand and gravel, we use boxes, which are set on the cars and which hold exactly the different batches in proportion to the amount of cement to be used. Allow the track to decline enough from the sand pile towards the mixer to make the loaded cars run without the need of pushing.

The cement house should be large enough to hold 300 barrels and built independent from the main building. It must be absolutely dry. When track is laid up to it, it requires only a short time in the morning to pile enough sacks on the cars to last a day and to deposit them near the mixer.

Do not neglect to have a good, dry place for the odd molds, which necessarily must accumulate on your hands.

Pile the blocks in the outside yards in piles of even numbers, say 400 pieces to the pile and mark the age of the blocks on each pile. It is very hard and tedious work to lift blocks from the cars and carry them the whole length of the pile. In order to avoid this, we have made a contrivance which does away with considerable of this work. It is a dolley, consisting of two hard wood rollers and a hard wood frame, about 12" wide and 24" long. After piling the first row of blocks on the ground, we lay short 4" strips on them. These are removed gradually, while the layer increases, then a block is put on the dolley and it is rolled to the further end of the pile. This is continued until the layer is of the same length as the lower one. Piling is always begun at the end farthest away from the track. In this manner it is possible to pile the blocks higher with considerable less work than you could otherwise, and also do away with too many drive-ways between the piles.

The buildings and outer yards must be kept in the best of order; provide a special place, if possible out of sight, for the broken pieces, which, by the way, may be utilized for underpinning small outbuildings and can always be sold to good advantage. Reserve a prominent place near the main entrance for displaying odd work and lay up a little wall, using thin, dark painted strips of wood to represent mortar and thus show off what can be done in the way of belt courses, cornice work, columns, etc.

DEVELOPMENT OF CONCRETE WORK IN THE STATE.

T. H. MacDonald, *Iowa State College.*

Results of Inquiries to County Boards.

The work done during the past year in the various counties of the state is quite indicative of the general attitude adopted toward the use of concrete in the construction of bridges, abutments, and culverts. The trend of opinion of the township and county road men alike is more and more toward this form of construction as the most suitable for such purposes.

In order to gain a general idea of the amount of work which had been done in the state during 1905 by the counties, a blank form was sent out to each county board asking for the number of arch or flat-top reinforced concrete bridges and culverts built during the year. As usual with such inquiries, the results were

not altogether satisfactory. Forty-five of the ninety-nine counties sent in reports which gave the following results:

Twenty-seven counties used no concrete during 1905, but of this number eleven had used concrete in either culverts or piers prior to last year; or else contracts were let for work to be erected during the coming year. This leaves fourteen, or about thirty-two percent of the total number of replies received, reporting no concrete used. It is possible that in some of these instances the report covered only one supervisor's district, and yet so many of the counties reporting "no concrete used" is indicative of the need of agitation and of the distribution of all possible information along this line.

Two counties, Decatur and Calhoun, report the use of concrete for piers and abutments only. Those reporting contracts let for work to be constructed during the coming year are Audubon, Carroll and Clinton. In a few cases the township road officers are taking up the work, as is reported from Wapello and Grundy counties. Among those reporting "no concrete used" are a number of counties in which there is every reason to believe the work has already begun, and the report must be incorrect or at least incomplete. The counties which have begun the use of this material are holding steadily to their course and building each year a number of permanent structures. The following schedule shows the work done in a number of these counties during the past year. The first schedule (A) is for the flat top culverts and the second schedule (B) is for the arch top culverts and bridges.

SCHEDULE "A".

FLAT TOP.

COUNTY	CULVERTS OR BRIDGES	COST
Black Hawk	4—26′ clear span—Thatcher bars	$3150.00
	2—23′ clear span 1 per cent x sec. area	2480.00
	1—20′ clear span 1 per cent x sec. area	460.00
Boone	14′ clear span 7-2000 lbs. I-beams	271.00
Bremer	4—12′ to 16′ spans—R. R. rails and ¾″ to 1¾″ steel rods—Average	125.00
Greene	16′ span—Kahn Bars	400.00
	5′ span—60 lbs. R. R. rails	195.00
Dickinson	5 x 5″—Top 5-8″ round rods—2″ c. to c. $6.00 cu. yd.	
Humboldt	4′—30 ft. long	165.00
Hamilton	2 x 2—38′ long—Barbed wire	76.40
	2 x 2—40′ long—Barbed wire	79.90
Poweshiek	4′—60′ long, Kahn 1′ c. to c. Concrete $7.50 per yd.	750.00
Story	4 x 6—16′ roadway	300.00
Washington	3′ span—3″ gas pipe—18″ c. to c.	190.25
Woodbury	6′ span—40′ long—Johnson bars and wire meshing	600.00

SCHEDULE "B".

ARCHED TOP—CULVERTS OR BRIDGES.

Black Hawk	17½' span—1 per cent section area Thatcher bars	$1200.00
Bremer	6'—6' to 8' span—barbed wire—Aver.	75.00
Hamilton	6 x 5'3"—40' long, 200 lbs. barbed wire	287.00
	5 x 6'4"—40' long, 200 lbs. barbed wire 3 x 4'6"—40' long, 120 lbs. barbed wire	300.00
Story	5' span	370.00
Tama	3—6' span at $9.45 per cu. yd.	
Woodbury	12' span— 8—¾" x 20'6" Johnson 20—¾ x 14' Johnson	800.00
Worth	16' span none	210.00
	8' span none	75.00

In addition to these, the following brick and stone arches are reported:

SCHEDULE "C".

Boone	Brick arch—5' span—50' long	$350.00
	Stone arch—5' span—34' long	164.00
Union	Brick arch—6 x 6—20' long—$13 per ft.	260.00
	Brick arch—6 x 6—26' long—$13 per ft.	338.00

Cost and Prices.

Particular attention is called to the range in prices as given for the different counties. This may be accounted for in a measure by the variation in the price of the materials delivered, and also the relative difficulty of pursuing the work under conditions imposed by the location of the structures. [However, these reasons are not altogether satisfactory when the range of prices is so wide. For instance, one county reports the work to cost 35c per cubic foot which means $9.45 per cubic yard, while another county reports the concrete to cost $6.50 per cubic yard. In each Portland cement and gravel were used and the difference in prices could not possibly be due to variation in the prices of the materials used]. A good example of the reasonable cost of concrete work under fairly favorable circumstances is the reinforced concrete bridge reported from Boone county. The abutments and wing walls are about seven feet high and eighteen inches wide on top, with a batter of about ½" to the foot on the outside. The top is a 14" slab of concrete with a clear span of 14 feet reinforced with seven lines of 6" I-beams having their ends embedded in either abutment. There is a 16 foot roadway with a 10" felloe-rail on either side and a two-rail gas pipe railing. Sand and gravel cost $1.00 per cubic yard and cement $2.00 per barrel plus haulage. The structure completed cost $271.00. The con-

struction of this bridge was in charge of Mr. V. O. Holcombe who is superintendent of bridges for that county.

As to the relative merits of the contract system and the day labor system on such work, an examination of the reports from the various counties showed that of those reporting which system was used, just half used the contract system and the other half the day labor system. For the ordinary small structures where the counties can find a thoroughly reliable foreman to take charge of the work, they will in most cases undoubtedly get the work done more economically by day labor, but for the larger structures and those entailing a considerable amount of machinery, equipment and engineering skill the contract system should be used. When this system is followed the county should not fail to have a man employed who thoroughly understands the work to inspect during the progress of construction and require the conditions of the contract to be fulfilled. The time to inspect concrete is while it is being mixed and placed in position—not after the structure is completed.

Concrete and the Materials Used to Make it.

To so many county and township men there seems to be a certain misunderstanding of the properties of concrete, and why certain conditions must be imposed upon its use to produce reliable results. While it is true that a certain amount of technical skill and knowledge must be employed in proportioning the materials and in designing the structures, the whole subject can be well understood by any county or township road official who will give to it intelligent thought. In the first place it is necessary to know the influence that each of the materials used in its composition has on the final product, and when these are understood such conditions as might be called theoretical or impractical will be found not only reasonable but essential.

(a) *Portland Cement.* The superiority of Portland cement over either natural or slag cements would recommend its use even to the exclusion of the others. The manufacture of this cement was first begun in 1827 and it takes its name from its resemblance in color when set or hardened to the stone found on the Isle of Portland. It is a product of the burning together of about 75 per cent of limestone and about 25 per cent of clay, finely ground and intimately mixed together and burned to the point of incipient vitrification, or the point at which the materials fuse, forming a clinker. This clinker is then ground to a very fine powder which is placed in bags or barrels ready for the market.

There are a number of very important considerations which affect the quality of the finished product, the first being the composition and proportioning of the raw materials. If the proportion of lime is too high the result will be a cement which sets

slowly and will likely contain "free" lime. If the proportion of clay is too high the clinker is likely to be overburned and the setting or hardening quality of the cement will be damaged if not destroyed.

There are also a number of substances, such as magnesia and sulphate of lime, which are regarded as impurities detrimental to the quality of the cement if found in any considerable amount, and the raw materials must be so chosen as to give low proportions of such impurities.

The second consideration is the burning or clinkering of the materials. Revolving, cylindrical kilns are used, the raw materials passing in at one end and issuing from the other in small black lumps or clinkers. Under-burning does not often occur except with a mixture having too high a proportion of clay or in consequence of some defect in the kiln itself. An example of this occurred where the product of a certain kiln was changed from a poor to a standard grade of cement by increasing the length of the kiln about 20 feet. Under-burning produces a quick setting, weak cement and one which would usually fail to pass the fineness test.

Over-burning is also apt to occur with a mixture having too high a proportion of clay, and the product will be a slow setting cement, deficient in hardening qualities.

To prove the quality of the cement a number of standard tests have been devised as follows:

(1) Tensile Strength,
(2) Soundness,
(3) Time of Setting,
(4) Specific Gravity.

These tests are reliable when conducted in a first class laboratory and there are sufficient "tricks of the trade" to make it desirable for prospective purchasers to order cement subject to the standard tests.

The Highway Commission has access to the cement laboratory of the Engineering Experiment Station at Ames and cement is tested for county or township officers at actual cost, which ranges from about $2.00 to $5.00.

The production of Portland cement in the United States for 1904 was 26,505,881 barrels, an increase of more than four million barrels over the 1903 output. Up to the present time there have been no cement factories in the state, but recently definite steps have been taken to establish a Portland cement factory at Mason City.

The prices paid for cement have varied considerably in the different counties, varying from $1.50 to $2.55 per barrel. The quotations for this spring are considerably higher than for a year ago, and it seems probable that cement will be quoted at

least fifty cents higher per barrel for the first shipments at least and the sales-agents give notice of even further advances in price. With the establishment of new factories, however, and increased output from those already in operation, it is not likely that the price will remain long above the quotations for the past year.

Reinforced Concrete.

Concrete beams or slabs when reinforced with iron or steel rods will safely carry two or even three times the loads of plain concrete. It can also be used for structures that would be neither safe or economical if built of the concrete alone. This is especially true of flat topped bridges and culverts which the Highway Commission is recommending for general use. The design is a simple box-shaped structure with wing walls, extending at each end at an angle of about 30° to the axis of the culvert. This shape was adopted for several reasons, chief among them being the simplicity of design and consequent ease of construction; forms that can be built at reasonable cost, and economical combination of steel and concrete. The forms for the smaller sizes can with care be used a number of times, which materially reduces the cost of each culvert. The dimensions of reinforcement for such structure recommended by the Commission is given in the following table taken from the report of the Committee on Roads and Pavements:

DIMENSIONS OF REINFORCED CONCRETE CULVERT TOPS.

Clear Span	Depth or Thickness	Reinforcing area per foot	Spacing of ¾ inch Corrugated Bars
2 feet	6 inches	0.60 sq. inches	11 inches c. to c.
4 feet	8 inches	0.84 sq. inches	8 inches c. to c.
6 feet	10 inches	1.08 sq. inches	6 inches c. to c.
8 feet	12 inches	1.32 sq. inches	5 inches c. to c.
10 feet	14 inches	1.56 sq. inches	4 inches c. to c.
12 feet	16 inches	1.80 sq. inches	4 inches c. to c.

DIMENSIONS OF REINFORCED CONCRETE CULVERT TOPS.

Height above bottom	Thickness	Reinforcing area per foot	Spacing of ¾ inch Corrugated Bars
2 feet	6 inches	0.30 sq. inches	20 inches c. to c.
4 feet	6 inches	0.30 sq. inches	20 inches c. to c.
6 feet	10 inches	0.54 sq. inches	12 inches c. to c.
8 feet	11 inches	0.60 sq. inches	11 inches c. to c.

"Ordinarily independent foundations are built for the side wall in the case of larger culverts and are connected by a 5 inch slab of concrete to protect from undermining. The reinforcing used amounts to 1 per cent for the culvert tops and ½ per cent for the sides. While corrugated bars are mentioned in the above tables the specifications provide for using plain bars if more convenient. The loads used in proportioning the covers of these

culverts are 600 lbs. per square foot, plus a concentrated load of 4800 lbs. (equivalent to a 16 ton road roller.)"

Steel for Reinforcing.

There are a number of patented forms of steel on the market which can be used for reinforcing, and in addition to these a number of common commercial forms of steel have also been employed by various counties. Barb wire for reinforcing is very good as it can be well distributed throughout the concrete, but the tendency is to use entirely too little as the cross section of the single wire is very small and a very large number of wires must be used to obtain a one per cent reinforcement which is recommended for the culvert tops. Barb wire also costs per pound fully as much as many of the patented forms. A number of counties during the past year have used the patented reinforcement for the culvert tops and have used old iron of various kinds for the side walls, abutments and other construction where great strength is not required, and this is a good practice. Taking into consideration the greater area required, the labor of using, and such factors, it is doubtful if for the important parts, particularly the tops, of the structure counties can use old iron such as railroad irons, eye bars and such material as economically as they could the regular reinforcing steel.

DISCUSSION.

Mr. Marsh—I would like to ask Mr. MacDonald why these bridges are calculated to carry such heavy loads when steel bridges are generally figured to carry one hundred pounds to the square foot with a factor of 4 and he calls for six hundred pounds to the square foot with a factor of about 10.

Mr. MacDonald—Mr. Chairman, I answer that by saying that these bridges are calculated to be put up by township trustees and county supervisors, men who have not had so much experience as contractors who are putting up the steel bridges and we have to make a pretty large allowance for the inexperienced man.

Mr. Marsh—I want to say that a gentleman in Chicago has gotten a patent on a reinforced concrete plank for use as a bridge floor. I believe our ordinary steel bridges are not calculated to carry a reinforced floor or a permanent floor of the ordinary construction as they are not heavy enough nor strong enough. He is getting ready to put these planks on the market and they look good to me.

Professor Marston—It should be said also in connection with these concrete bridges and culverts that that includes the dead weight of the cover which may be as much as three hundred pounds to the square foot or perhaps more and that does not make the comparison quite so strong as otherwise it might seem. Anoth-

er reason for adopting these heavy loads is that it is possible to get the strength with the concrete at a cost that is very reasonable and we want not only a good bridge but the very best.

THE ABUSES OF THE CONCRETE INDUSTRY AND ITS REMEDIES.

S. W. COOMBES, *Iowa City, Iowa.*

Mr. Chairman and Gentlemen of the Convention:

My subject is a far-reaching one, and one that needs prompt and vigorous treatment. I have for twenty years been handling Portland cement concrete, mostly in finished work, such as sidewalk, curbing, culverts, foundation and finished floor work, and in this time have observed many pieces of work, where good material was destroyed by persons who were ignorant of the nature of the material used. Others destroyed good material by a dishonest desire to realize more profits. In one city I might name a so-called cement contractor who distributed circulars stating that "Millions walk on my walks. I make walks, others try." The result was that inside of one year the top or finish coat was loose and all of the gravel in contact with the top came away with it. The base of the so-called concrete was loose, like gravel; it apparently had very little cement in it; or if sufficient cement was used, it certainly was not properly mixed.

There are a great many of this type of grafters doing business today in all branches of the concrete business all over the state of Iowa. Many concrete men use a given proportion of sand, gravel, stone and cement, regardless of its aggregate relation, as to voids or dirt. Perfect concrete is that wherein all voids are filled and every particle of aggregates in its composition is covered with cement. Concrete of this kind properly put in place and properly cured, will never be a source of trouble to its maker. Again we find that many loose tops are the result of (1) too little water being used in the concrete to cause adhesion of the cement and aggregate by crystallization; (2) by top troweling after the initial setting had begun, and (3) by using a top or finish too rich in cement, which causes its shrinkage or expansion to be different from that of the concrete base.

Many pay very little attention to the symmetrical appearance of the work, thereby destroying the beautifying effects of perfect work. Many pay very little attention to the mixing of either concrete base or top. I have taken up work and found the so-called concrete streaked, some parts being very strong with cement and other parts almost clear sand. In this particular case the parties blamed the cement.

Again many city engineers make a specification and compel sidewalk contractors, in clay ground, to dig a ditch, six or eight

inches deep, and in this place sand or gravel, on which to build the walk. The winter rains or thaw comes, the water runs under the walk and fills the voids in this sand or gravel filling, there being no place provided for drainage. Then Old Boreas comes and freezes it, making an almost solid sheet of ice 6 or 8 inches thick under the walk. (What heaves more than ice?) In the spring the ice thaws from the outside, leaving a ridge or backbone of ice lengthwise of the walk, for it to break over. If it is not a very strong walk, indeed, it will break sooner or later.

In the making of cement blocks the same rules apply as in any other branch of the industry. I have in mind some blocks that I bought to underpin an old three story brick building. The maker of these blocks had no jam or piece blocks, all being the regulation 2-foot blocks and corners, said to be made 4 to 1. I cut these blocks with an old hand saw (they were that soft). In order to make the work stronger I filled all the hollow spaces with good cement mortar.

We have a prominent building contractor that would use cement blocks in his work if they were made stronger and more like stone in appearance. He very much dislikes the dull gray appearance of most cement blocks, as well as the sameness of the blocks, it looks artificial. Cement concrete, properly made, is bound to become the permanent building material of the future.

REMEDIES.

Manufacturers of concrete in any form should be honest in their work. and if they don't know how to properly make concrete, get a foreman that does, and insist that he does it or get out of the business. He should see that there is used:

1st.—Care in proportions.
2nd.—Proper mixing.
3rd.—Proper sand, gravel, stone and cement.
4th.—No dirt in material used.
5th.—Plenty clean water.
6th.—Proper curing of work when done.
7th.—Good washed and screened gravel and sand.

It may be said regarding the percentage of voids found by actual test that, too much cement is waste and too little is a sure cause for failure. The maker of concrete to be successful must adhere strictly to the proper percentages of all material used. Dishonest competition, the desire to get the almighty dollar without an equivalent is the cause of a great many abuses of the concrete industry, and the remedies must be vigorously applied to overcome them.

To insure that proper work be done I would advocate a stringent state law, to regulate the crushing strength of all cement blocks or concrete of any kind used in building, and make the

inspector of buildings responsible for any failure on the part of the block maker or building contractor to comply with the law.

In many cities the city engineer is also inspector of the sidewalks. Some of them do not properly inspect or enforce the ordinance specifications relative to sidewalk building. I would advocate as a remedy for poor cement walk-making that we reccommend an ordinance governing the city specifications of such city, making the inspector and city responsible to the property holder having work done under such ordinance, and putting said inspector under a heavy security bond to protect the city, and assure it that his work was properly done. This would, in my opinion, eliminate the grafter and the inexperienced workman, thereby insuring honest and reliable work, as well as the success of the cement concrete industry for all time to come, and in future history this will be known as the concrete age.

BUSINESS SESSION.

Mr. Humphrey—I would like to make a request that I made at Milwaukee. This was made because there was some criticism of the illustrated talks that were given, that there are no pictures shown of what was being done with the concrete blocks. I often have occasion to use a great many lantern slide illustrations with cement in various forms and I would certainly appreciate any photographs or illustrations from members of this Association that feel interested enough to send them. I can make good use of them as I have big demands from people who want illustrations of work that is being done with concrete block, particularly in the West. Any pictures of cement that is used on the farm such as were described this morning I would be glad to receive. Any charges in connection with it I should be glad to pay. I must say that I have received only about a dozen photographs; surely there must be more pictures taken than that.

Mr. Metzgar—I want to take up the matter of a safe-guard to the builder of cement sidewalks in Iowa, a request to the Legislature of Iowa to enact a law as a safe-guard to the sidewalk industry. Now the proposition that I submitted yesterday was this; while the Legislature of Iowa has enacted laws in the interests of farmers and laws that have been a safe-guard to the saloon keeper and to the landlord of hotels, there is no safe-guard to the Iowa sidewalk builder in his work which enhances the value of adjoining property nor in making highway improvements under municipalities. He can whistle for his pay. I want to submit this question to this body of cement users in convention here at Ames in the year of our Lord, 1906; that a committee of three be appointed by the Chair to draft a resolution along these lines as a memorial to our present Legislature. I put this in order to

get it before the convention. I move you, Mr. Chairman, that this convention ask of the Legislature and insist that every man that is in this Convention now shall be a committee in his own district to correspond with the member from his district and insist that he do this as a safe-guard to the makers of the improvements along thoroughfares and highways. I move you that this convention ask the present Legislature to enact a law making properties adjoining structural work holden by lien, the same as with carpenters and plumbers. I know exactly what I want to say but I do not know just exactly the words to use. You can contract with the individual and he put you off from time to time as regards payment and finally throw in your face that the law of Iowa gives him the privilege of not paying.

Mr. Dickinson—I think it is constitutional. it is so in Illinois anyway. The sidewalk builder has a direct lien on the property for his sidewalk. I move that a committee of three be appointed to draft those resolutions.

The Chair named to serve on this special committee, Messrs. A. E. Metzgar, Thos. H. MacDonald and H. F. Carlon, who drafted the following resolution which was accepted by the convention:

Your Committee on Special Resolutions recommends that the amending of Section 3089 of the Code relating to Mechanics Lien be referred to a committee which shall report at the next meeting of this body. Signed.

A. E. METZGAR,
THOS. H. MACDONALD,
H. F. CARLON.

REPORT OF COMMITTEE ON SPECIFICATIONS FOR HOLLOW BLOCK.

Mr. Miracle—Mr. Chairman, Gentlemen of the Convention; your committee on specifications for hollow blocks begs to report as follows: We have printed copies of the specifications that were adopted by the Northwest Concrete Products Association. We have been unable to find one of the members of the committee but Mr. Gabler and myself went over these very carefully and Mr. Gabler found no criticisms to make. They are:

SPECIFICATIONS FOR HOLLOW BLOCKS.

DEFINITIONS.

Sand.—Such material as will pass through a screen ¼ inch mesh and is retained in screen having No. 40 mesh. This applies to river sand, bank sand, or screenings from a stone crusher.

Gravel.—Such stone or rock, obtained either from a bank or river, of such size as is retained in a screen having ¼ inch mesh.

Crushed Stone.—Such stone from a crusher as is retained in a ¼ inch screen.

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WIND MILLS

*R. M. Dyer, Seattle, Wash.**

HISTORICAL.

A short historical review of the windmill used as a prime mover will be necessary to establish a basis upon which some of our later arguments and facts may be founded. While not intending to develop the historical side of the question beyond the necessities of our topic, the references offered will enable anyone sufficiently interested to thoroughly investigate all relative points.

Aside from a single author, Alfred R. Wolff, whose work has been published in an original (1885) edition, and a later revision of the same, no one has ventured to treat the subject, historically, scientifically and as practically applied. The experiments of Smeaton in 1755 and later, and of Coulomb in 1820 are taken by general writers as authoritive, although Coulomb's lacked all features of exactness and thoroughness, while nearly every careful investigator has found errors and unwarranted conclusions in the records of Smeaton.

Whether or not windmills were used prior to the Tenth Century is not clearly established. The type of wheel which we know as the "Dutch Wheel" evidently developed about that time and for 700 years held its own with but few variations. The "Dutch Wheel," so called because used in such great numbers in Holland, consisted of a main shaft, supporting four radiating arms, carrying light framework to support the canvas or other

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sail material; the main shaft communicating the power when produced to the machinery which usually consisted of a paddle wheel water pump, a millstone, or a stamp mill.

These mills were turned up to the wind by hand power, sometimes the whole mill turned on a pivot, sometimes the upper half only, and later only the top of the mill which carried the main shaft and windmill.

The earliest effort to improve the operation of these mills, aside from various changes in size, shape and angle of sail, is recorded in 1780 when a device for reefing the sails while in motion was made by Andrew Miekle. This device, as well as that of Sir William Cubett (1807) designed for the same purpose was accomplished by the effect of centrifugal governors. To the last named inventor belongs the credit of first using an auxiliary windmill set at right angles to the plane of the main wheel to keep the windmill headed up to the wind without the constant attention of the attendant.

Weisbach and Rankine also have had something to say in reference to windmills, windmill sails, wind pressures and the theoretical power of a theoretically perfectly designed windmill. But to Mr. Thos. O. Perry belongs the honor of having been the first to make a series of tests, experiments and actual trials upon which modern windmill construction is based. The work was also done as recently as 1880 to 1885 and of this we will speak later.

A few windmills of the Dutch type were built in America. Two of them stand within a few hours' trolley ride from Chicago, but for the purposes for which such power could be best used, that of pumping water, a design of mill gradually developed in America, known as the "American Windmill," being a small wheel 12 to 20 feet in diameter, almost filled with wooden slats. This style of mill held its own for many years in its crude form.

Daniel Halliday made the windmill a safe and practical machine by inventing and perfecting a wheel, the sails of which were connected up in groups or sections, which pivoted under control of centrifugal governor balls and thereby held the mill to a reasonably safe speed at all wind velocities. The Halliday interests were afterward taken over by the existing company, "The United States Wind Engine and Pump Company" of Batavia, Illinois. The Halliday method of governing had and has many imitators but none seem to have equalled the original.

Another favorite method of governing used by the early builder of windmills was the "Solid Wheel with Side Vane," a small vane being attached rigidly to the frame which carried the head of the wheel which would turn the wheel edgewise or partly edgewise to the wind when acted upon by winds above normal velocities. Variations of these two methods of governing formed

the basis of innumerable patents between 1860 and 1890, during which time the manufacture of wooden windmills flourished and the number of manufacturers increased to a score or more.

The Leffel wheel made at Springfield, Ohio, between 1880 and 1885 showed the first departure from seemingly fixed methods of regulation in having the wheel set off from the center line of the vane, thereby avoiding the use of the small side vane, the force of the wind acting directly on the face of the wheel to bring it out of sail as the wind velocity increased above normal. The wheel was made with a sheet iron wheel and with a wooden vane.

Passing over the development of the steel windmill as now generally made of which we will treat fully in a later chapter, we might call attention to the various freak wheels which from time to time appeared that you may be warned not to give time or other valuable consideration to machines that will certainly give no adequate return.

The inventive genius of the pioneers on our western plains, where winds are plentiful and powerful seem to be able to raise an annual crop of new and useless windmills even in seasons too dry to return the seed wheat that was sown. Numerous magazine articles have described these mills during the last four years. Even scientific papers (so called) have collected data on the subject. For recent information you might refer to the Cosmopolitan Magazine of December, 1903, for information on this topic. Incidentally we might sum up the subject of freak wheels as follows:

Wheels of the paddle wheel form with shield to protect part of the wheel from wind action are worthless.

Wheels which require the paddles or the sails to "flat" when acted upon by the wind and feather edgewise when moving against the wind are worthless.

And third, wheels which require some special shape of paddle, sail or bucket, one side of which will present a more advantageous surface to the wind than the other are worthless.

Without discussion it might be said that they are impossible from a manufacturing point of view.

MODERN DEVELOPMENT.

The actual development of the windmill wheel as we know it was due primarily to the work of Mr. Thomas O. Perry. Mr. Perry was and is a gentleman of scientific and mathematical attainments and had interested himself for some years previous to 1882 in the development of the windmill and other machinery used in agricultural pursuits. At this time a preliminary study of Smeaton's and Weisbach's theories convinced him that the

data upon which their deductions had been made, lacked thoroughness and completeness; that the assumptions upon which these formula had been based were, in part, erroneous, and that the wheels which had been used to develop the empirical elements of their equations were poorly suited to produce satisfactory results.

He, therefore, developed by strictly theoretical and mathematical means, a new set of formula and made several startling suggestions in reference to improvements in windmill design. It might be mentioned that instead of using the elements of pressure and velocity of the wind as the basis of his power formula he used the more rational factor "Kinetic Energy" of the air current intercepted by the wheel. He also took into consideration (somewhat incompletely and with conclusions peculiarly erroneous) the disposition of the spent air current after passing through the wheel. This work was not made public, except by being submitted to several well known scientific men, Professor Thurston among others, for criticism.

In 1883 a laboratory was fitted up by the Halliday Company in Batavia, Mr. Perry being placed in charge, to test out on an elaborate scale his theory in reference to the design of windmills, as well also to test the forms of wheel that several others had suggested. We might add here that the results of this laboratory work indicated a design of wheel so divergent from anything in use that the company did not deem it advisable to undertake to make the change, and, in fact, did not improve their wheel until other parties brought out wheels of such improved design that they were compelled to adopt the new form of wheel.

The work on this subject has been published in full by the United States Geographical Survey, Department of the Interior, under the title of "Water Supply and Irrigation Papers," Pamphlet No. 20.

The following points, which were fully covered by these tests and experiments were established by several thousand tests on many forms of wheels.

Form of sail: necessity of a thin sail, angle of sail or "weather," effect of various obstructions before and behind the wheel; effect of obstructions within the wheel such as wheel arms connecting members of the wheel, etc., proper amount of sail surface, speed of wheel, relative to velocity of wind, and, in fact, every question which had arisen at that time bearing on the design of wind wheels. These results when considered in the light of manufacturing possibilities required some modifications, but so closely were they followed that no gain in power of any wheel made since the first Aermotor was built has been claimed by the designers, and, in fact, it is generally understood by the 32 manufacturers, that the wheel next best to the Aer-

motor is the wheel that is nearest to the Aermotor in design. The Aermotor is here mentioned, as it is the wheel actually designed by Mr. Perry and afterwards made a manufacturing possibility and a success by the president of the Aermotor Company, Mr. LaVerne W. Noyes.

Experiments developed that the old flat wood sail was not as efficient as the curved steel sail, the angle of weather was chosen most favorable for a light wind, 4½ to 5 miles per hour being utilized with some efficiency.

Any windmill will run in a high wind, but a well designed mill must work in a light wind. A mill that requires a ten mile wind, may run only four or five hours per day, a mill that will run in a five mile wind will probably run eighteen hours per day in this locality.

Experiments developed the fact that 7/8 of the zone of interruption could be covered with sails; that more than this was detrimental, and that the gain in power in from 3/4 to 7/8 of the surface was so small that the use of the additional material was not justifiable; that the sail surface should extend only two-thirds the distance from the outer diameter to the center; that a wheel running behind the carrying mast is not nearly as efficient as one running in front of the mast; that there should be the least possible obstruction behind the wheel; that to be efficient the velocity of the travel of the vertical circumference of the wheel should be from one to 1 1/4 times the velocity of the wind, hence the necessity of back gearing to reduce the pump speed to 40 strokes per minute as a maximum, which is the limit of safety at which ordinary pumps can be operated.

The pamphlet above referred to may be studied with profit by anyone desiring to be more fully informed on this subject, but a large mass of the data contained must be culled out to get at the facts, which point the way to actual improvement and development. According to Professor Rankine, it would be impossible to obtain a greater efficiency than 50 % of the actual Kinetic energy of the wind.

Perry records that with his experimental wheel he actually developed 44% of the kinetic energy of the impinging air current; however, if an efficiency of over 35 % is sought for, a comprehensive study of the physical elements entering into the absorption of the kinetic energy of an intercepted air current by a wind-motor operating under the most favorable conditions of wind velocity, curvature of sail, amount of sail surface and travel of sail, will show that the high rate of sail travel becomes prohibitive if such wheels are to be considered in view of their cost and maintenance either as a manufacturing possibility or as an economic motor.

Theorists hope that some inventive genius may be able to overthrow Rankine's limit, and produce a wind motor which will absorb and deliver perhaps 90 or 95 % of the total kinetic energy of the wind as does an improved Pelton water wheel absorb that percentage of the energy of the impinging stream. However, I hold that no manufacturer will be able to produce a marketable motor which will absorb and deliver, when acted upon by an elastic fluid, like air, in which it is entirely surrounded and submerged, more than 35% of the kinetic energy of the impinging current.

ON POWER OF WINDMILLS.

Theoretical demonstrations show that the intercepted area of air current varies as the square of the diameter of the wind wheel and that the Kinetic energy of the air, impinging on such an intercepted area varies as the cube of the wind velocity; consequently, we might say that the power of windmills of the same type varies as the square of the diameter, and as the cube of the wind velocity. This is true within reasonable limits, but as the wheel is designed to give its best efficiency in low winds, say ten to fifteen miles per hour, we cannot expect that the same angle of sail would obtain the same percentage of efficiency in winds of considerably higher velocity.

The ordinary wheel works most efficiently under wind velocities of from ten to twelve miles per hour, such wheels will give reasonable efficiency in from five to six mile winds, while if the wind blows more than twelve miles per hour, we will have power to spare. Our wheel must work in light winds, such being nearly always present, while the higher velocities only occur at intervals.

Mills built for grinding purposes, geared mills, or power mills as they are called, when attached to a grinder, having a centrifugal feed, will develop power almost approaching to the cube of the wind velocity, within reasonable limits of such velocity, as their speed need not be kept down to a certain number of revolutions per minute, as in the case of the pumping mill.

Should this theoretic condition hold, the following table, showing the amount of power for different sizes of mills at different wind velocities would apply: Figures show Horse Power.

Size	5 mile	10 mile	15 mile	20 mile	25 mile	30 mile	35 mile	40 mile
8. ft....	.011	.088	.297	.704	1.375	2.176		
12 ft....	.025	.20	.675	1.6	3.125	5.4	8.57	12.8
16 ft....	.045	.36	1.215	2.88	5.52	9.75	15.3	21.04

These figures have been proven by laboratory tests at velocities ranging from ten to twenty-five miles per hour and more practically by the Murphy tests on mills actually in use, which show very close relation at the wind velocities at which the mills are best adapted.

The Murphy figures are as follows:

Size of mill	10 mile	15 mile	20 mile
12 ft.	.21 H.P.	.58 H.P.	1.05 H.P.
16 ft.	.29	.82	1.55

For higher wind velocities the Murphy values fall much under the theoretical values, but the range of velocities over which his experiments extend do not justify any change in the general law except in as much as common sense teaches us that theoretic conditions can rarely be attained in actual practice.

In view of the fact that a windmill does not work as efficiently in high winds as in winds under 20 miles per hour my experience would lead me to believe that the following figures (HP) would be the probable extension of the Murphy tests:

Size of mill	25 mile wind	30 mile wind	35 mile wind	40 mile wind
12 ft.	2.5	4	5	6
16 ft.	4.	6	8	10

A 20 ft. mill would deliver approximately 50% greater than a 16 ft.

The foregoing table must be translated with reasonable allowances for conditions under which wind wheels must work and which cannot well be avoided. e. g. Pumping mills must be made to regulate off at a certain maximum speed to prevent damage to the attached pumping devices. The regulating point is usually between 20 and 25 mile wind velocities, so that no matter how much higher the wind velocity may be the power absorbed and delivered by the wheel will be no greater than that indicated at the regulating point.

Again, owing to the peculiar construction of power of geared mills, the torque of the vertical shaft operates to prevent the mill from regulating off; consequently, when working, the mill is held up squarely to the wind, until the load imposed by the attached devices ceases to absorb all of the power which the mill will deliver. After this condition obtains any increase in wind velocities causes the mill to regulate or turn out of the wind. The regulation point on such mills when loaded is, therefore, usually placed at wind velocities of from 30 to 35 miles.

In pamphlets Nos. 41 and 42 of the Water Supply and Irrigation Papers of the United States Geological Survey, Mr. Edward Charles Murphy has recorded an exhaustive series of tests

on all kinds of mills working under ordinary conditions, either favorable or unfavorable. The result of Mr. Murphy's tests did not vary in any considerable degree from data already known to us, but coming from a strictly disinterested party, employed by the Department of the Interior to make such tests and investigations, his work is taken as authoritative, and has been of great value to us both as a means of checking up our own records, as well as a safe guide to which we can refer the doubtful and the unbelieving.

The Murphy pamphlets showed such superior results attained by the Aermotors tested as compared with mills of other makes that we have secured the privilege from the proper authorities to use some of the Murphy data in our advertising literature.

Another series of tests have been carried out by Prof. F. H. King of the University of Wisconsin, published in April, 1900, as Bulletin No. 82, of the Agricultural Experiment Station of the University of Wisconsin. Prof. King's tests dealt more particularly with geared or power mills, grinding attachments and comparative data concerning the cost of operating grinders or such farm machinery by means of windmills and gasoline engines.

With Prof. King's permission we are able to publish his work in full for distribution to our friends.

We might pause at this point in our discussion to record such references as might be followed by those who might wish to inform themselves on the various topics treated by the literature relative to our subject.

On the construction and effects of windmill sails by John Smeaton, F. R. S., read before the Royal Society, May 31st and June 14th, 1759, recorded in the Philosophical Transactions of the Royal Society, London, Volume XI, 1755-63, can be found on file in the Cornell University Library, republished later in Tredgold's Tracts on Hydraulics; Conlomb's Theory of simple Machines, Paris, 1821, referred to in most Encyclopedias; Alfred R. Wolff's Windmills, 1885, Weisbach, Reauleaux, Rankine, and, in fact, almost all of the writers on Hydraulics, Fluids, and similar topics, the Standard Encyclopedias, and the well known handbook author, Kent, treats theoretically on the subject. However, the first mentioned, which remained unequaled and unapproached for over 125 years, followed by Rankine's Steam Engine, page 195 to 210, Perry, Murphy, and Prof. King, hold all that is really worth while; all others having merely manipulated data without developing the empirical elements necessary to make their formula practicable or usable; not including the publications of the Aermotor Company, which has circulated, as advertising medium, an enormous amount of literature on the subject, the

most important of which is contained in the Aermotor descriptive catalog, in the regular and power editions, which will give all needed data and information on the subject to anyone who wishes information in practical windmill work only.

Another subject which needs some consideration is the fact that while the power of a mill increases approximately as the square of its diameter the weight of the machine increases approximately as the cube of its diameter. To explain this more fully: The 8 foot Aermotor will produce 33 foot pounds of work per minute for each pound of material in the wheel in a fifteen mile wind. A 12 foot wheel 22 foot pounds per pound of material and only seventeen foot pounds can be developed to the pound of weight with a 16 foot wheel. Should the size of the mill be materially increased above 20 feet in diameter, which is the largest steel wheel made, the weight, and, consequently the cost, of the mill increases to such a degree that the manufacture of such mills is not advisable. Or, finally, in 8 and 12 foot mills more power is realized per dollar of investment than on larger sizes; also for large powers, a series of 12 or 16 foot mills coupled electrically, or by air compressing devices seems to be the most economic method of obtaining large power.

It is useless to waste time in a discussion of the comparative merits of wooden and steel windmills, while giving due credit to the excellent workmanship and the extreme care in the selection of the material used on some of the old wood wheels which have stood so long in some localities as to have become historical landmarks. The wood wheel as generally constructed is an inefficient, short-lived affair, designed without reference to the principles of wind dynamics.

Actual tests have shown that some wood wheels under certain wind conditions will give more power with every alternate slat removed, and on wood wheels having slats ½" thick and 3" wide, the efficiency of the wheel is reduced nearly 1-6 merely from the action of the wind on the edge of the slat.

As to the comparison of power: An 8 foot steel Aermotor will do work equal or greater than a 12 foot wood wheel. A 12 foot Aermotor will equal an 18 foot wood wheel and a 16 foot Aermotor will equal a 24 foot wood wheel. Mr. Murphy records one case where a 12 foot Aermotor equaled in power a 22' 6" wood wheel, and I have seen in the Southwest several 16 foot Aermotors pumping into the same tank with wood wheels, 24, 26 and even 28 feet in diameter from wells of same depth and with pumps of same size and construction, observation showing that the Aermotor raised at least 25% more water per month than the large wood wheels.

SOME REASONS FOR THE SUCCESS OF THE AERMOTOR.

The real beginning of the windmill business occurred in 188[illegible] when Mr. La Verne W. Noyes realized the possibilities of the windmill business when the design and manufacture of such machines should be conducted on a basis of science, common sense, manufacturing possibilities and public demand.

Mr. Noyes' previous experience in the manufacture and sale of agricultural machinery, as well as his natural ability as an inventor, organizer and a "doer of things" enabled him in less than four years to break down all prejudice against steel windmills and do over half the world's windmill business through the office of the Aermotor Company. Even at this date with thirty-two imitators in the field the Aermotor Company does more windmill business than that of all other so-called wind mill manufacturers put together. This result has not been accomplished by the superior quality of the goods only, nor by the low prices which have been made on the goods but because Mr. Noyes believed that to build up a permanent business, the windmill using public needed to be informed as to the best methods of erecting mills and towers, of caring for them and of selecting and arranging the various attachments which are to be operated.

The Aermotor Company would rather lose the sale of a mill than have it improperly put up, overloaded, neglected, or given insufficient wind exposure. The Aermotor Company would rather refuse to do business through a salesman, agent, or dealer, no matter how many thousands of dollars of business the party might turn in annually, rather than have its goods put up in an unsatisfactory manner.

The original principles laid by the Aermotor Company relative to the installation of windmill outfits have done more to build up the windmill business than all other advertising matter sent to prospective customers.

First: A windmill must have a good wind exposure. We have defined this as being at least fifteen feet above all wind obstructions within four hundred feet.

Second: High towers of proper construction are more satisfactory than low towers as the mill is raised up into the steady air currents instead of being subjected to the shifting, eddying ground currents.

Third: Careful inspection and frequent oiling of the motor. A windmill makes more turns in a month than the main shaft of a binder or mower does in its lifetime; consequently, the necessity of frequent lubrication with oil which will not run or evaporate in summer heat, or harden or gum in winter's cold.

Fourth: Proper loading. In the case of pumping mills, the pump, cylinder, piping, etc., must be properly proportioned

to enable the mill to run in a light wind and not damage the pump or mill at its maximum speed. Former pump makers have been accustomed to use large pump cylinders and small pipe on hand pumps, thereby deceiving the customer by making him believe that he was getting a pump of large capacity. Such pumps would operate fairly well with a wood windmill as such mills never would run fast enough to damage the pump in any kind of a wind. From that condition of affairs the Aermotor Company set down as a principle that for smooth, rapid pump action, the delivery pipe, pump openings, etc., should be at least one-half the diameter of the cylinder.

Again I repeat that the excellent design of the Aermotor together with the infinite care used in its manufacture has had no more to do with its wonderful growth in popularity than has the insistance of the Aermotor Company on the creed of high towers, sufficient wind exposure, properly proportioned pumping attachments, good workmanship at installation and intelligent care thereafter.

Under this topic it might be mentioned that the steel tower for windmill use, built and introduced by the Aermotor Company has had much to do to improve the appearance and stability of windmill outfits, as well as making the equipment a complete article of carefully designed proportion, thereby avoiding the insecurity due to the use of wooden towers, which are always subject to wreckage, owing to decay of timbers, checking or cracking of timber exposed to the weather and poor design, as such towers are usually built by carpenters or country workmen who have had but little experience, and but the slightest knowledge of the strength of the material or the strains to which the structure is to be subjected.

PRACTICAL METHOD OF DESIGNING TOWERS.

In building a steel bridge or a roof truss it is the common practice to carefully estimate the strength required by each and every member and then to make the structure, 4, 6 or 8 or 10 times as strong as may be required by the actual load which the structure is designed to carry.

Such an extravagant use of material would make a windmill tower too heavy and too expensive for general use. A more rational method of tower design has been adopted. For example: We decide to build a tower of new design. After carefully considering the strength required in the several members of the structure, a tower is built and actually subjected to the strains which the tower must stand in use. Should any member show weakness it is strengethend up. Should the design prove faulty it is corrected and by such procedure the final design

of the structure is decided upon, giving us a tower in which each member has exactly the strength required, in which no excess of material is used in any part. There is not a pound more nor a pound less of material than is required in any part of the structure, resulting in a saving to the customer and a feeling of confidence by the manufacturer, which enables him to guarantee his structures.

Mr. Noyes, to whom the development of the steel tower is due, observed the principle, that in a structure of pyramidical shape, that is, a tower having its main corner members battering or tapering toward each other at the top, so that such members could be firmly joined at the apex, any strain imposed on the tower at this apex, in a direction perpendicular to the axis of the pyramid would be transmitted to the base of the tower, as a compression or tension upon the corner posts, without straining any of the horizontal or diagonal bracing members of the tower, except as much as would be required to withstand the incipient buckling of the corner post.

This fixing of the apex of the tower rigidly is, therefore, the keystone in the arch of successful tower building, and the Aermotor way of doing it, by notching the corner posts, and clamping them around a pipe, a system covered by broad original patents, has been neither equalled nor approached by other designers or manufacturers.

Another important point in the manufacture of light steel work which is to be exposed to the atmosphere is its protection from the elements.

Early in the making of steel windmills and steel towers the Aermotor Company decided that paint at best made only a temporary protection and was quite as likely to deceive the owner of a windmill outfit by concealing rust spots in the structure as it was to protect the structure from rust. At an enormous expense a galvanizing plant was installed, in which 75 tons of zinc could be kept in a melted state the year round, enabling every piece of steel used in the manufacture of wheels and towers to be galvanized after all holes are punched, and after all forming, shearing and riveting is done, thereby thoroughly coating every part of the steel work with an almost indestructible coating of zinc.

While on the subject of towers, some consideration might be given to the steel towers for supporting tanks which were brought out first of all by the Aermotor Company; that is, towers of such simple design and construction as to enable the ordinary country artisan to assemble and erect them with ease and safety.

By advocating the use of wells sunk deep enough to insure a constant supply of pure water by getting below the strata which carries the surface water which is both uncertain in sup-

ply and filthy in composition the Aermotor Company has done much to promote the health of both men and cattle.

By advocating the use of elevated storage tanks which enables water under moderate pressure to be carried to all parts of the house, barn and premises the chore of "watering the stock" has been reduced to a minimum for the farmer and the farmer's son, while the many trips from kitchen to the old pump which may be saved by a water tap at the kitchen sink has done much to lighten the dreary labor of the patient housekeeper.

The "Gospel of the bath tub" which usually follows the installation of a pressure water service brings peaceful sleep to the tired farmer after a day's toil which has been aggravated by dust and perspiration and is only objected to by the small boy who believes that the only water fit for use is that in the old swimming hole under the willows.

THE DEPRECIATION OF ELECTRICAL PROPERTIES

*By G. W. Bissell**

As a preliminary to the preparation of this paper the writer sent to each member of the association a letter propounding and asking replies to the following inquiries:—

1. In computing the total cost of your output, do you make allowance for depreciation?

2. If the answer to No. 1 is affirmative, how much depreciation do you charge off, and how do you arrive at this amount?

3. How do you invest your sinking fund?

Twenty replies were received. Three answered question 1 and 3 in the negative, without explanation or other sign of interest in the matter, and, of course, gave no answer to question No. 2.

Four members answered question No. 1 in the negative, but explained that circumstances, such as pressure for dividends, prevented the practice, or that extensive renewals of deteriorated property had prevented allowance for depreciation, or that the plant was not yet old enough to be affected by depreciation; but all four evidently appreciated the importance of the subject.

Two members took issue against the recognition of depreciation as an account to be considered in making a true book showing of the property. Attention will be called to these arguments later.

One member answered question No. 1 in the affirmative and No. 3 in the negative, and evidently confused depreciation and maintenance.

The remainder, ten in number, gave affirmative and more or

*A paper read at the meeting of the Iowa Electrical Association, Des Moines, April 19, 1906.

less complete answers to the three inquiries, and quotations from the letters are here presented.

(1) "We set aside about five per cent. of gross investment each year for maintenance of property."

(2) "We use the replacement value of the plant equipment as a base on which to figure depreciation. * * * The fund derived from these amounts is deposited in the bank as a time deposit and draws interest. It can only be withdrawn by consent of our board of directeors. All amounts realized from sale of replaced machinery, scrap, wire, or any part of our equipment, is credited to this account. Sinking fund is for bond redemption only."

(3) "Upon the actual cost of our plant we figure a depreciation of 8 per cent., and invest the amount where we can find and receive the best interest rate."

(4) "Charges of 8 per cent. annually, investing not to exceed one-half in improvements and the balance in the bank at 4 per cent. per annum for replacements."

(5) "We figure 6 per cent. for depreciation in computing the cost of current, but have never been able to create a sinking fund to take care of the item. We consider 6 per cent. a low figure."

(6) "We charge 5 per cent. of our total investment each year for depreciation. Ten years' experience shows that this is not enough, hereafter the charge will be 7 per cent.

"Depreciation is the one thing that makes electric lighting in a small town a poor business."

(7) "As a rule, electric installations are without sufficient capital. They soon find themselves face to face with the proposition of providing for their extensions and depreciation, and at the same time meet the expectations of the stockholders for dividends. It has been our custom to put sufficient money into the plant each year in the way of repairs to maintain its value. The objection to this plan of providing for depreciation is that it is not uniform. One year we have little or no repairs, while next year the repairs are excessive.

"In the present state of business I should think a fair allowance for depreciation would be from 8 to 10 per cent on the cost of construction. While it is true that electric apparatus as built to-day perhaps has a life of more than ten years, still in readjustment of things occasioned by the growth and development of the business and the growth and development of appliances, our past experience would indicate that we will rarely ever use a piece of machinery more than ten years.

"We believe that a fixed per cent. on original cost should be placed in the sinking fund each year to provide for depreciation, and that this sinking fund should be invested to the best pos-

sible advantage; but we think you will find very few companies in Iowa providing a sinking fund.

"It is not wise for a manager to overlook this item, because it is something that must be provided for, and while he may be able to evade it for a few years, it will finally present itself in an aggravated form, and there is no escape."

(8) "We had no bonded indebtedness until May, 1904, when a mortgage of $650,000 was given to secure a bond issue in like amount. The entire proceeds from the sale of bonds, with an additional $100,000 advanced by the stockholders on the company's note, was put into the reconstruction of the property. The physical condition of the plant previous to the reconstruction was exceedingly bad, and the entire income was required for repairs and operation, leaving no surplus for dividends or other purposes.

"The following provision is made for a sinking fund:—

"'A sinking fund shall be created and maintained during the uncancelled existence of this mortgage for the payment, in part, of the principal of the bonds hereby secured, and shall consist of the payment in the sum of $15,000 on the 30th day of April in each year on and after April 30, 1906, by the company to the trustees, which annual payment company agrees to make to the trustees.

"'It is further provided that the trustees shall hold the annual payments until the disbursement thereof, allowing the company interest thereon, this interest to be added to the sinking fund annually. The money so accumulating shall be used from time to time for the purchase by the trustees of the bonds at a price not to exceed 5 per cent. par; the bonds so purchased shall be cancelled and delivered to the company.'

"You will note that the annual payment of the $15,000 is not effective until 1908. We are, with the commencement of the current year, however, charging off 20 per cent. of the gross receipts each month to depreciation and maintenance. From this amount we subtract the actual maintenance cost for the month, the balance being charged to depreciation.

"In my opinion there are few companies in the state which have a broad provision for depreciation and sinking fund. This provision should undoubtedly be made, otherwise, at the expiration of the life of the bond issue, the property will be sadly depreciated in value and no funds in hand to put it in the same physical condition as at the issuance of the bonds.

"Capital is becoming more insistent that sinking fund provisions be made, although the majority of bond issues now in effect carry no such provision."

The above quotations and other information contained in the letters of the members who believe in and practice the recog-

nition of depreciation as a factor in central station finance, are from cities of from 3,,000 to 50,000 population widely distributed over the state. Evidentl some plant managers are thinking hard over the question.

Reference has been made to members presenting arguments against depreciation as an element of productive cost. One member writes:—"In regard to depreciation, I will say that I differ from most people on this subject. We do not charge off any depreciation. When any part of our machinery gives out, we repair it or replace it with new and charge it to expense. If a pole is decayed and unsafe, we replace it with a new pole and charge it to expense, and so on through the entire system. In this way we pay for our depreciation as it comes. We classify our accounts to a certain extent. We have an account for meters, transformers, coal, repairs to boilers, station supplies, equipment, etc. Meter repairs are charged to expense, and new additional meters are charged up to meters. A new meter to replace an old one is charged to expense, and similarly with transformers, etc. Annually, or as often as desired, we can balance up our accounts and see how we stand."

But he concludes with this statement:—"If a plant is making more than a fair dividend, I would set aside some of it for a surplus and put it in a good bank at interest. Then, in case of a breakdown or extension of plant, there would be some ready money."

It would seem as though the last statement qualifies materially the non-belief in depreciation accounts, and that the writer really would charge off depreciation if his business would pay him well enough to enable him to do so.

Another member writes:—"If a plant is earning sufficient money to take care of the maintenance, which must include all replacements and renewals and interest on the investment, and has anything left, it would seem better to pay it to the stockholders in extra dividends than to run the risk of holding it in a sinking fund. Keeping the fund safely would be a problem. Keeping it profitably invested would be still more of one, but when it is paid to the stockholders as it accumulates all this is avoided."

To this view of the case there might be presented the question:—How will these same stockholders feel if extraordinary expense, such as replacing obsolete equipment, necessitates an assessment, and how much worse will their heirs or assigns feel who have not directly received the previous large dividends? Is it not better to anticipate such a contingency by having a fund to meet it?

The object of depreciation as a book-account is, according to Ewing Matheson, so to treat the nominal capital on the books

that it shall represent as nearly as possible the real value. Theoretically, the most equitable method of doing this, if feasible, would be to revalue everything at stated intervals, and to write off whatever loss might be thus revealed without regard to any prescribed rate of depreciation.

"This plan, if strictly carried out, has in practice some disadvantages. The two leading considerations in such an appraisement are generally the condition of the property and its earning power. In both these respects there may be absolutely no sign of deterioration; a machine may appear, and for all practicable purposes be, as good as new, and may show proof of it by actual earnings. Yet none the less its working life is shortened year by year, and unless some provision is made for replacement a severe loss will fall on the future. And if, recognizing this, something is written off the value, though no alteration is apparent, then a depreciation rate is in fact applied.*

*The Depreciating of Factories—Matheson, p. 24.

"The question of depreciation cannot be separated from that of maintenance, and in theory one may be said to balance the other. In practice it is only in certain cases that this can be acted on. In any particular building, machine, or appurtenance, decay or wear of some sort must take place in the course of time, and repairs, in order to compensate fully for the decline in value, must take the form of renewal.

"This being the case, the absolute replacement of some portion of the plant every year may maintain an average aggregate value. In only two kinds or classes of plant, however, can such an exact balancing of loss by repairs and renewals be ventured upon: one, where the plant wears out so quickly as to need complete replacement at short intervals, and in a second class, that of undertakings so large and permanent as to afford a wide annual average of deterioration and renewal over the whole plant."

In short, depreciation account provides insurance against those losses in value which cannot be met by current repairs and minor renewals, which are intangible until some future time when the equipment is found to be unsafe or obsolete and inefficient in view of advance in the state of the art.

Depreciation may be based upon a uniform rate for all parts of a property. This is an easy way, as far as figuring is concerned, but requires rare judgment in its application to so complex an undertaking as an electrical property.

Depreciations may be based upon an average rate of the several rates of depreciation proper to the component parts of the plant. The correct method of finding the depreciation rate is exemplified in the following problems:—

Suppose a power plant to consist of:—

Buildings and chimney worth $25,000, having an estimated useful life of 50 years.

Boilers and auxiliaries, worth $20,000, having an estimated useful life of 15 years.

Engines and generators worth $30,000, having an estimated useful life of 12 years.

Switchboard worth $2,500, useful life 10 years.

The depreciation period may be assumed at 50 years.

The depreciation is sometimes obtained as follows: —

Buildings	$25,000	× 1-50	$ 500.00
Boilers	20,000	× 1-15	1,333.33
Engines	30,000	× 1-12	2,500.00
Switch-board	2,500	× 1-10	250.00
	$77,500		$4,583.33

$4,583.33 ÷ $77,500 = 5.9 per cent.

which result is correct if the annual amount of $4,583.33 charged to depreciatioon draws no interest.

Another method is to obtain the average life of the whole plant, as follows:—

$$\begin{array}{rcr} \$25{,}000 \times 50 & = & \$1{,}250{,}000 \\ 20{,}000 \times 15 & = & 300{,}000 \\ 30{,}000 \times 12 & = & 360{,}000 \\ 2{,}500 \times 10 & = & 25{,}000 \\ \hline \$77{,}500 & & \$1{,}935{,}000 \end{array}$$

$1,935,000÷$77,500=25 years.

from which the rate or depreciation would be 4 per cent. and the annual charges would be $3100. This is too small, as appears from Table I:—

TABLE I

Life Years	Value of Part	Times to be Renewed in 50 Years	Total Renewal Expense in 25 Years	Years	Dollars, Years
50	$25,000	1	$25,000	50	$1,250,060
15	20,000	3 1-3	66,666 2-3	15	1,000,000
12	30,000	4 1-6	125,000	13	1,500,000
10	2,500	5	12,500	10	125,000
	$77,500		$229,166 2-3		$3,875,000

$3,875,000 ÷ 229,166 2-3 =16.9 years.

77,500 ÷ 16.9=$4,583 = 5.9 per cent.

229,166 2-3 ÷ 50 = 4,583 = 5.9 per cent.

It is probable that the energetic plant manager would keep his depreciation allowance or sinking fund invested. Suppose that it is possible to safely count on 3 per cent. compound interest on the continual contributions to the sinking fund in the above

assumed problem, the annual charge to depreciation would be obtained as follows:—

For each part of the plant, find what sum at 3 per cent. will amount to the redemption value in the term of years estimated as the life of the part.

Thus, for the buildings worth $25,000 and estimated to last 50 years, interest tables (see Kent's Hand-book, 5th Edition, p. 16) show that an annual payment of $8.87 at 3 per cent. compound interest will in 50 years amount to $1000. Therefore, $221.75 so invested will furnish the sum for replacing the building at the end of 50 years.

For the whole plant the several depreciation items computed in this way are presented in Table II:—

TABLE II

Life	Value of Part	Annuity per $1,000 at 3 per cent	Annuity for Actual Value	Same at 4 per cent	Same at No Interest
50	$25,000	$8.87	$ 221.75	163.75	500.00
15	20,000	53.77	1,075.40	998.80	1,333.00
12	30,000	70.46	2,113.80	1,996.50	2,500.00
10	2,500	87.24	218.10	208.25	250.00
Total annual charge.....			$3,629.05	$3,367.35	$4,583,00

From this it appears that the total annual charge for depreciation is $3,629.05, as compared with $4583 where the sinking fund is non-earning.

The rate of interest in any given case should be very conservative in order to cover errors of judgment in overestimating the natural life of the part or to provide for premature renewal due to extraordinary causes. In case the parts of the plant last longer than was expected, the accumulated depreciation charges can be held stationary until such part does need renewal and the usual annual charge used in some other way—to increase dividends or surplus or to offset errors in the other direction as to depreciation in other parts of the plant.

As to the method of investment of the depreciation sinking fund, there are several avenues for ready money. Improvements in the plant or extensions are legitimate if they will pay the interest on which the annuity is based. Otherwise they are not. A line ten blocks long to supply lights to one or two houses at the end would not be remunerative enough for this purpose. It should be constantly borne in mind that the depreciation allowances are each specific, and their use for other purposes should not be tolerated. Repairs and maintenance must be regarded as distinct from depreciation sinking fund and otherwise provided for.

It should not be understood from the above discussion that the rate of depreciation is assigned once and for all at the begin-

ning of an enterprise and not subject to modifications. The point to be emphasized and driven home is that the fact of depreciation is real and must be met at the outset, or later calculations and business transactions will be very disappointing to the man or corporation whose money is at stake.

As to the life to be assigned to the various parts of electrical properties, there "are many men of many minds."

Dawson, in his "Engineering and Electric Traction Pocket-Book," page 1265, suggests:—

Buildings 50 to 100 years.
Water turbines 11 to 14 years.
Boiler, 10 to 12 1-2 years.
Engines and generators, belted, 10 to 20 years.
Belts, 3 to 4 years.
Large, slow-speed steam engines, 15 to 25 years.
Ditto, direct-connected, 12 1-2 to 25 years.
Stationary transformers, 15 to 20 years.
Storage batteries, 9 to 11 years.
Trolley line, 12 1-2 to 25 years.
Feeder cables, 20 to 35 years.
Meters, 10 to 12 1-2 years.
Cars, 15 to 25 years.
Motors, 12 1-2 to 20 years.
Rotaries, 10 to 12 1-2 years.
Spare parts, 50 to 75 years.
Track work, 7 to 13 years.
Binding, 10 to 16 years.
Sundries, 16 to 25 years.

On some of these items the figures are too high for average American practice, because we do more temporary work than Europeans and make our equipment work harder.

Some members of this association have given the following:

Buildings, 25 years—the franchise life, 33 years, 50 years.
Boilers, grates, etc., 14 to 15 years.
Piping, 14 to 15 years.
Pumps, 10 years.
Engine condensers, 12 1-2 years.
Foundations, 12 1-2 years.
Station wiring, 12 1-2 years.
Switchboard, 10 years.
Poles, cross-arms, 12 1-2 to 10 years.
Wire, 25 years.
Arc lamps, 8 years.
Meters, 10 years.
Transformers, 12 1-2 years.
Whole plant, 20 years, 16 2-3 years, 14 years, 12 1-2 years.
Real estate is supposed not to depreciate.

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Method

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the curve and afterward taking measurements from it, errors are introduced besides requiring a large amount of unnecessary work. It is necessary to take only as many readings with the contact maker as ordinates are needed in the analysis of the curve.

It is taken for granted the reader is familiar with the general discussion or if not is interested only in the rule here given and which may be applied without a knowledge of the theory upon which it is based.

An important fact which seems to have been lost sight of by most of the previous writers is that for absolute accuracy of analysis an infinite number of ordinates must be used and a series with an infinite number of terms developed. Further that as the number of ordinates is diminished not only is the number of terms diminished which form the series but the ordinates of each harmonic is increased in the terms which are retained. As the number of ordinates becomes quite small, say 8 or 12, this becomes quite appreciable in the third and fifth and especially in the seventh harmonic unless the series is very convergent. This was pointed out in particular by Harrison in his discussion referred to above. As an illustration of the importance of this point a curve, (A. C.), was analysed by S. P. Thompson's method using 12 ordinates and the amplitudes of the 1st, 3d, 5th and 7th harmonics obtained were 2.94, 1.33, 0.5, and 0.39 respectively. When analysed by the rule given in this paper using 18 ordinates the values were 2.94, 1.27, 0.49, and 0.17. The error becomes greater the higher the harmonic desired.

It will thus be seen that if reasonable accuracy is desired in the fifth and higher harmonics, the number of ordinates cannot be made less than 18 or 19. On the other hand as was pointed out by S. P. Thompson, as the number of ordinates is increased the calculations involved increase in about the square of the ratio. Hence it is desirable to use the fewest ordinates that will give the desired accuracy. In the opinion of the writer this should be either 19 or 37 for the usual alternating current curve.

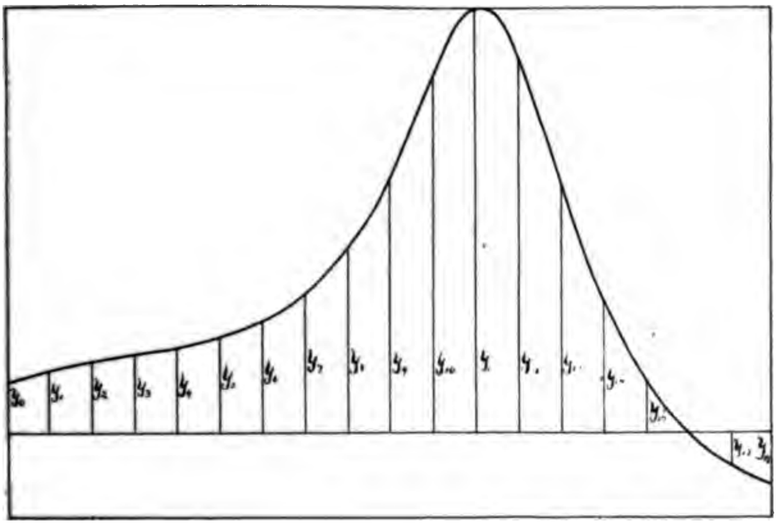
Much time is saved in the taking of the readings if the curve is not plotted as only 19 readings need be taken at intervals of 10 electrical degrees. It will be seen from Rungi's discussion that it is not necessary that the first and last ordinates should be zero as is the case in applying S. P. Thompson's rule. This difference only requires the addi-

tional work of adding and subtracting three or four more quantities while it enables the operator to begin readings on the contact maker at any point he chooses.

The following rule is adapted directly from that of Rungi above referred to by omitting all that pertains to the even harmonics.

Let us suppose that the readings as taken by the contact maker are $y_0, y_1, y_2, \text{———} y_{19}$. These readings if plotted would form the following curve.

PLATE I.



These may be arranged conveniently in the following table and hence the rule:

Write the ordinates observed as follows:

$$\begin{array}{l} y_0,\ y_1,\ y_2, \text{ — — — — } y_8,\ y_9, \\ \underline{y_{18},\ y_{17},\ y_{16}, \text{ — — — — } y_{10}.} \end{array}$$

Sums ·	$s_0,\ s_1,\ s_2,$ — — — — $s_8,\ s_9,$	for sine comp.
Differences	$d_0,\ d_1,\ d_2,$ — — — — $d_8,\ d_9,$	for cosine "

Be careful in each case to retain the proper algebraic signs.

For the sine components the further simplification may be made by combining all of the coefficients of the same sine into one single value. Thus,

For the Third Harmonic,

$s_1 + s_5 - s_7 = s_1'$

$s_2 + s_4 - s_8 = s_2'$

$s_3 - s_9 = s_3'$

For the Ninth Harmonic,

$s_1' - s_3' = s''$

For the cosine components in the same way the further simplification may be made.

For the Third Harmonic,

$d_0 - d_6 = d_0'$

$d_1 - d_5 - d_7 = d_1$

$d_2 - d_4 - d_8 = d_2'$

For the Ninth Harmonic.

$d_0' - d_2' = d''$

These quantities should now be placed in the following table *after being multiplied by the sine of the corresponding angle.*

	SINE COMPONENTS					COSINE COMPONENTS				
HARMONIC	1 17	3 15	5 13	7 11	9	1 17	3 15	5 13	7 11	9
sin 10°	s_1		$-s_7$	$-s_5$		d_8		$-d_2$	d_4	
sin 20°	s_2		s_4	s_8		d_7		$-d_5$	d_1	
sin 30°	s_3	s_1'	s_3	$-s_3$		d_6	d_2'	d_6	d_6	
sin 40°	s_4		s_8	s_2		d_5		d_1	$-d_7$	
sin 50°	s_5		s_1	s_7		d_4		d_8	$-d_2$	
sin 60°	s_6		$-s_6$	s_6		d_3	d_1'	$-d_3$	$-d_3$	
sin 70°	s_7		$-s_5$	s_1		d_2		$-d_4$	$-d_8$	
sin 80°	s_8		s_2	$-s_4$		d_1		d_7	d_5	
sin 90°	s_9	s_3'	s_9	s_9	s''	d_0	d_0'	d_0	d_0	d''
1st Col										
Totals										
2nd Col										
Sums	$9A_1$	$9A_3$	$9A_5$	$9A_7$	$9A_9$	$9B_1$	$9B_3$	$9B_5$	$9B_7$	$9B_9$
Diffr's	$9A_{17}$	$9A_{15}$	$9A_{13}$	$9A_{11}$		$9B_{17}$	$9B_{15}$	$9B_{13}$	$9B_{11}$	

The equation of the curve is therefore

$$y = A_1 \sin 10^\circ + A_2 \sin 20^\circ + A_3 \sin 30^\circ + \text{———} A_{17} \sin 170^\circ$$
$$+ B_1 \cos 10^\circ + B_2 \cos 20^\circ + B_3 \cos 30^\circ + \text{———} B_{17} \sin 170^\circ$$

Hence there are two waves of the nth harmonic, one a sine wave and the other a cosine wave. These may be combined into a single sine wave thus:

$$y_n = A_n \sin nt^\circ + B_n \cos nt^\circ = \sqrt{A_n^2 + B_n^2} \sin (nt^\circ + \theta_n)$$

If t=o, in the first member, the right hand member will give the value of the ordinate at zero.

$$B_n = \sqrt{A_n^2 + B_n^2} \sin \theta_n$$

Again,

$$\theta_n = \tan^{-1} \frac{B_n}{A_n}$$

Since the sign of B_n and A_n are given we can determine the sign of the tan θ_n and hence the sign to be used before the radical.

We are now prepared to plot as many of the harmonics as we choose and if desired, to compound them into the alternating current curve.

Let us consider a numerical example. Find the first, third, and fifth harmonics of the above curve.

The values of the ordinates are as follows:

	.56,	.72,	.83,	.90,	1.00,	1.12,	1.3,	1.63,	2.16,	2.9,	
	–.56,.	–.38,	0.00.	.66,	1,62,	2.94,	4.4,	4.96,	4.10,		
Sums:	0.00,	.34,	.83,	1.56,	2.62,	4.06,	5.7,	6.59,	6.26,	2.9,	for sin
Diff's:	1.12.	1.10,	.88,	.24,	.62,	1.82,	3.1,	-3.38,	1.94,	2.9,	for cos

For the sine component and third harmonic.

$$.34 + 4.06 - 6.59 = 2.19 = s_1'$$
$$.83 + 2.62 - 6.26 = -2.81 = s_2'$$
$$1.56 - 2.9 = 1.34 = s_3'$$

and ninth harmonic,

$$-2.19 + 1.34 = .75 = s''$$

For the cosine component and third harmonic.

$$1.12 + 3.1 = 4.22 = d_0'$$
$$1.10 + 1.82 + 3.33 \quad 6.25 = d_1'$$
$$.83 + 2.62 + 1.94 = 3.49 \quad d_2'$$

and ninth harmonic,

$$4.22 - 3.49 = .73 = d''$$

These may now be placed in the table multiplying each by the sine of the angle opposite to which it is to be placed before writing it down.

SINE COMPONENTS.

	1	17	3	15	5	13	7	11	9
.1736	.059				—1.7		—.705		
.3420		.283				—.895		—2.14	
.5000	.78		—1.19		.78		—.78		
.6428		1.72				4.02		.532	
.7660	3.11				.26		5.03		
.8660		4.93		—2.43		—4.93		4.93	
.9307	6.18				—3.815		.32		
.9848		6.15				.815		—2.581	
1.0000	2.9		—1.34		2.9		—2.9		—.75
1st Col. Totals	13.029		—2.43		—1.575		.965		
2ndCol.	13.083		—2.43		—.990		.542		—.75
Sums..	26.112		—4.86		—2.565		1.507		—.75
Diffs...	—.054		—0.00		—.585		.423		—.75

Hence, A_1 = 2.90 A_3 = - .54 A_5 = - .284 A_7 = .168 A_9 = - .084

A_{17} = - .006 A_{15} = 0.00 A_{13} = - .065 A_{11} = .046

COSINE COMPONENTS

	1	17	3	15	5	13	7	11	9
.1736	— .335				— .144		— .107		
.3420		—1.14				.62		.375	
.5000	—1.55		—1.74		—1.55		—1.55		
.6428		—1.17				.71		2.14	
.7660	— .474				—1.48		— .635		
.8660		.204		—5.4		— .208		— .208	
.9397	— .78				.581		1.82		
.9848		1.08				3.28		—1.79	
1.0000	1.12		—4.22		1.12		1.12		—.75
1st Col. Totals	— .459		—5.96		—1.473		.655		—.75
2ndCol.	—1.022		—5.4		—2.158		—.516		
Sums..	—1.481		—11.36		—3.631		.139		—.75
Diffs...	.563		.56		.685		1.171		—.75

Hence, B_1 = -.164 B_3 = 1.26 B_5 = - .404 B_7 = .016 B_9 = .08

B_{17} = -.062 B_{15} = .062 B_{13} = .078 B_{11} = .130

Therefore the amplitude of the first harmonic is $\sqrt{2.9^2+0.164^2} = 2.94$, and the ordinate at the origin, B_1 is $-.164$.

The amplitude of the third harmonic is $\sqrt{.54^2+1.26^2} = 1.27$ and its ordinate at the origin B_3 is 1.26.

The amplitude of the fifth harmonic is $\sqrt{.284^2+.404^2} = .494$ and the ordinate at the origin is $B_5 = -.494$.

The amplitude of the seventh harmonic is the same way, .169, and its ordinate at the origin B_7 is .016.

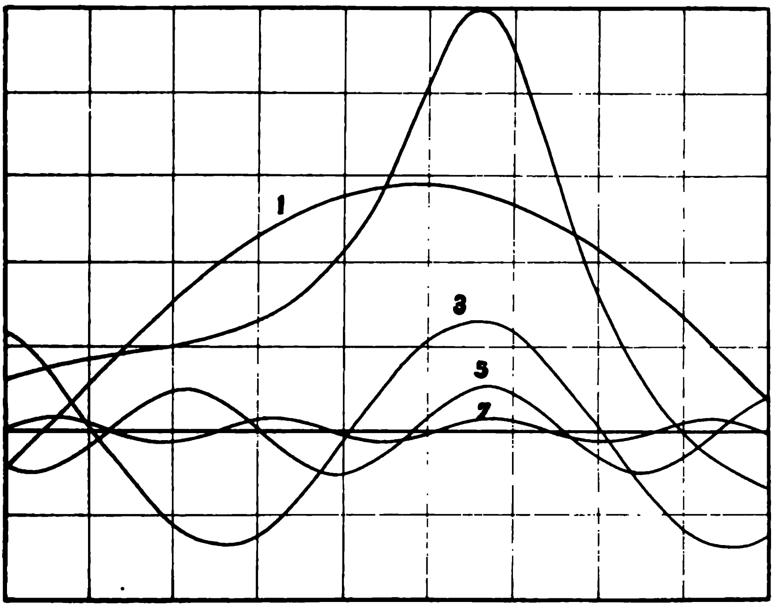
The phases at the origin are $\theta_1 = \tan^{-1}\dfrac{-.164}{2.95} = -3^\circ\ 40'$,

$\theta_3 = \tan^{-1}\dfrac{1.26}{-.54} = -66^\circ\ 50'$, $\theta_5 = \tan^{-1}\dfrac{-.404}{-.284} = 54^\circ\ 50'$,

$\theta_7 \tan^{-1}\dfrac{.016}{.168} = 50^\circ\ 24'$.

These harmonics and their resultant curve are shown in Plate II.

PLATE II.



A STUDY OF TIN-LEAD ALLOYS AS SOLDERS

J. W. AND R. I. CAUGHEY.*

The use of tin-lead alloys as solders, though universal, has been little investigated. It would, therefore, seem to offer a profitable field for research. In the set of experiments outlined below it was desired to learn something of the following points.

I. Methods of Making Soldered Joints.
II. Tensile Strength of Soldered Joints.
III. Electrical Resistance of Solders.

The materials upon which the joints were made were copper and brass, and are designated in the following discussion by B. for brass and C. for copper. The test pieces were ¾" round, each half being 5" long, and threaded for convenience in placing in the testing machine. The pieces were also centered at the threaded end. Some idea of the test pieces may be obtained from Plate 1. The solders used were made from "commercially" pure tin and lead. The percentages are by weight. The various solders will be designated by the content of tin, as 60% or 90% solder, it being understood that the remaining percent is lead.

Kester soldering paste was used as a flux. The joints were broken in a Tinius Olsen 50,000 pounds, hand operated testing machine.

Although the experiments upon methods of making soldered joints and upon tensile strength of soldered joints were carried on together, they will be discussed separately.

METHODS OF MAKING SOLDERED JOINTS.

So far as could be determined, there is no standard or approved method of soldering joints. The method first employed was the simplest one possible. The surfaces to be soldered together, were "tinned" or alloyed with solder and each piece grasped in a pair of tongs. The ends to be united were held in the flame of a blow-torch, until the solder was fused, then pressed together and held until the solder "froze." The joints so made had a fair degree of strength, but were objected to because it was impossible to properly align the halves of the test piece.

The next method tried was that of "sweating." In "sweating" these joints together the pieces were tinned, placed between centers, one of which was advanced by a heavy

* Thesis, 1905, Division of Engineering, Iowa State College.

spring, and heated until the solder was fused. All joints so made were greatly lacking in strength, being inferior to those made by the first method. The pressure was then varied

PLATE I.

from the greatest possible (100 lbs.) to the least that would move the test piece. No appreciable difference in the joints resulted.

The apparatus shown in Plate 1, consisting of a section of wrought iron pipe having a suitable groove for aligning the test pieces was then devised. At first it was not used with the pieces separated as shown, but the upper piece was allowed to rest upon the lower one, the upper clip being omitted. These joints were also lacking in strength, being substantially like those made by the second method.

The next and final step was to support the upper piece above the lower, by a wire clip as shown in Plate 1. The solder being fused by means of two blow-torches, the upper piece was gently pressed upon the lower one. This was the only method by which satisfactory joints could be obtained. This seems to indicate clearly that any pressure whatever upon solder at the moment of melting, greatly reduced the strength of the joint. To illustrate this, the series of joints shown in Plates 2, 3 and 4 were made. The joints shown in Plate 2 were made with the weight of the upper half of the test upon the solders during fusion. In Plate 3 an additional weight of 30 pounds was placed upon the upper half of the test piece. In Plate 4 the upper half of the test piece was supported by a wire clip, as previously described. These joints were all broken under a tension of 11,000 lbs. per square inch. Those joints made with light and heavy pressure, upon the solder during fusion, do not differ materially. The life of those joints made without pressure was much greater than those made with pressure. As shown by the plates these joints also differ in appearance. Those joints made with pressure are invariably more or less granular or spongy, while those made without pressure are usually smooth and firm.

PLATE 2.

PLATE 3.


LIFE OF JOINTS UNDER TENSION OF 11000 Lbs PER SQ IN
JOINTS SWEATED TOGETHER UNDER HEAVY

PLATE 4.

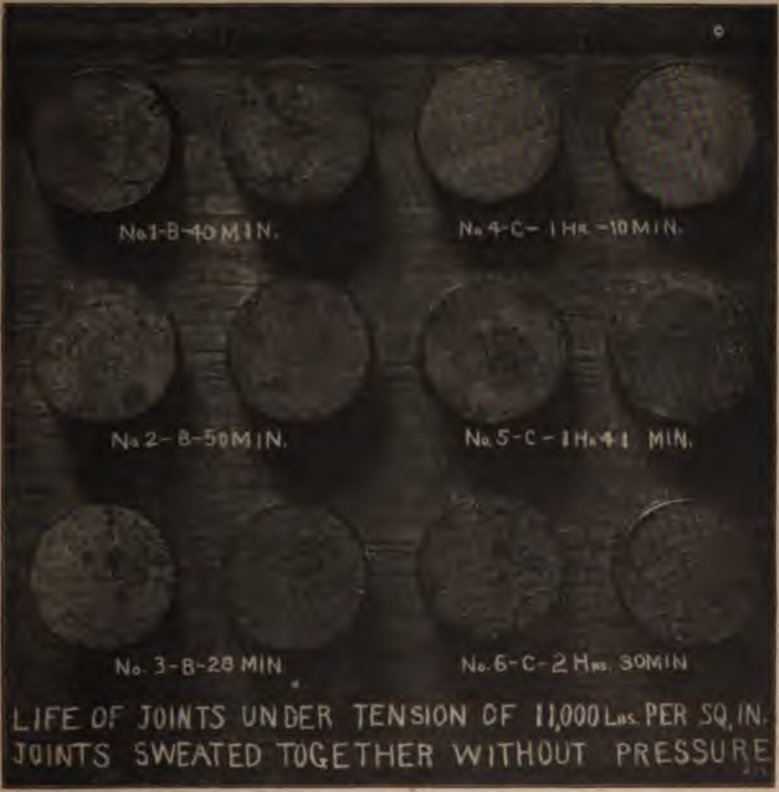

No.1-B-40 MIN.
No.4-C-1 HR.-10 MIN.
No.2-B-50 MIN.
No.5-C-1 HR.41 MIN.
No.3-B-28 MIN.
No.6-C-2 HRS. 30 MIN
LIFE OF JOINTS UNDER TENSION OF 11,000 LBS. PER SQ. IN.
JOINTS SWEATED TOGETHER WITHOUT PRESSURE

PLATE 5.

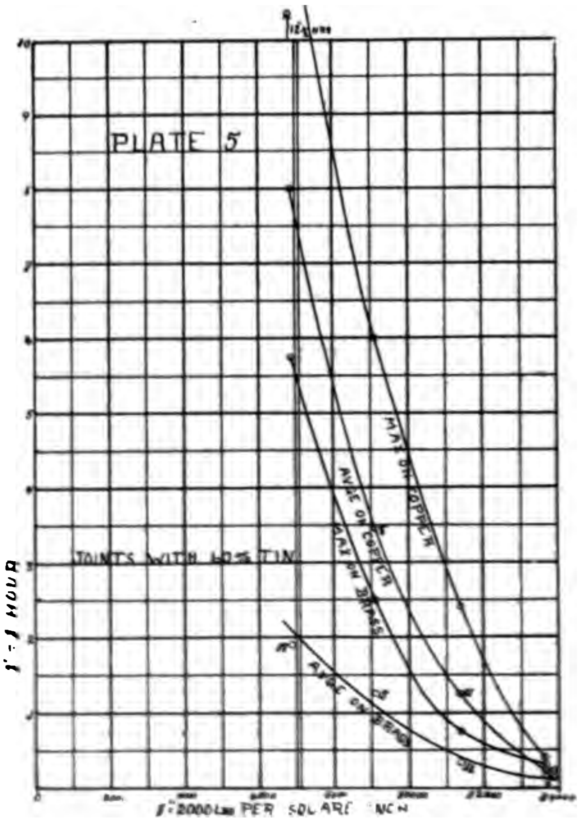


PLATE 5
JOINTS WITH 60% TIN
MAX ON COPPER
AVGE ON COPPER
MAX ON BRASS
AVGE ON BRASS
1" = 1 HOUR
1" = 2000 Lbs PER SQUARE INCH

STRENGTH OF SOLDERED JOINTS.

It was first proposed to determine the ultimate tensile strength of soldered joints made with solders containing various percentages of tin and lead. Although it was known that soldered joints would, after a time, fail under a stress much less than that required to produce failure at once, it was not thought that this time element would prevent a reasonably accurate determination of the ultimate strength. However, repeated trials showed that the time element could not be eliminated. For instance, a decrease of 5 seconds in the total time of testing increased the strength 4000 or 5000 lbs. per square inch, the total time of testing being 20 to 25 seconds. It might be of interest to mention that the maximum strength obtained was 25,900 lbs. per square inch. This joint was on copper with solder containing 60% tin. Total time of testing was 20 seconds.

It having been found impossible to eliminate the time element, experiments were made to determine whether a definite relation existed between load and life. For this purpose a number of joints were made on copper and on brass with 60% solder. These joints were loaded from 6,800 lbs. to 13,600 lbs. per square inch. The life of these joints is shown in Plate 5. The results give both the maximum and average strength obtained. The number of determinations made at each load is shown on the Plate. The average strength of a series of soldered joints depends largely upon the skill of the workman, while the most indifferent workman must occasionally make a perfect joint. This would seem to indicate that more comparable results could be obtained from maximum, than from average values, hence the reason for inserting them.

In order to make a comparison of solders containing various percentages of tin and lead, a series of joints were made upon brass and upon copper, with solders containing from 35 to 70% of tin. These joints were all broken under a load of 13,000 lbs. per square inch. Both the maximum and average results are shown in Plate 6. These results suggest some of the peculiarities of solders. Consider, for instance, the strength of joints on copper: It is seen that the maximum strength increases with the percent of tin. The average strength increases up to 60% tin, then decreases. A possible explanation of the decrease in the average strength

of joints made with 70% tin is, the extremely narrow temperature range in which perfect joints can be made. A temperature a few degrees above the melting point produces such extreme fluidity that the solder flows out of the joint. The values for 60% in Plate 6 are taken from Plate 5.

In order to determine the life of soldered joints, under light loads, a series of joints were made upon number 8 copper and brass wires, with solder containing from 10 to 90% tin. These joints were hung up in eight strings and loaded with weights corresponding to from 350 lbs. to 3850 lbs. per square inch. The life of the joints is given in days in Plate 7. The joints which are left remained unbroken after ninety-six days. It will be noticed that in general the joints on brass have a longer life, under a given load, than those on copper. This is the opposite of what was found to be true under heavy loads as shown in Plates 5 and 6.

PLATE 6.

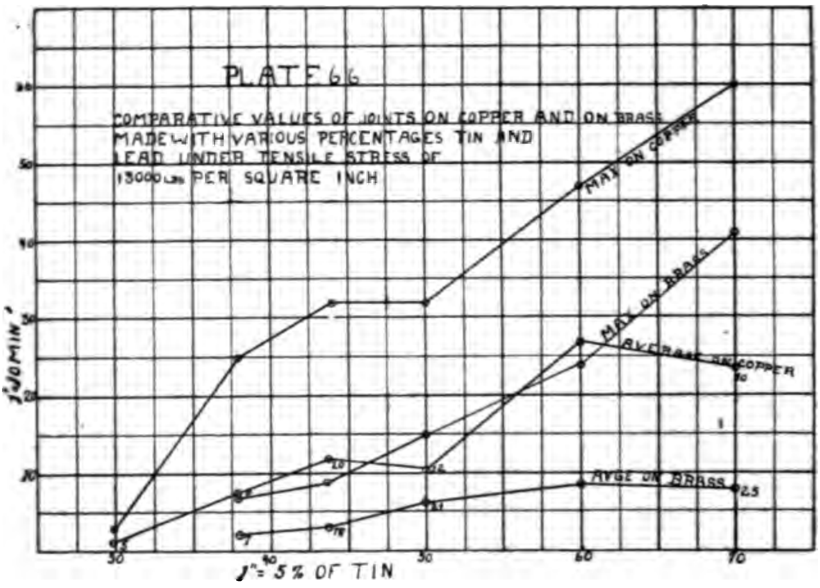


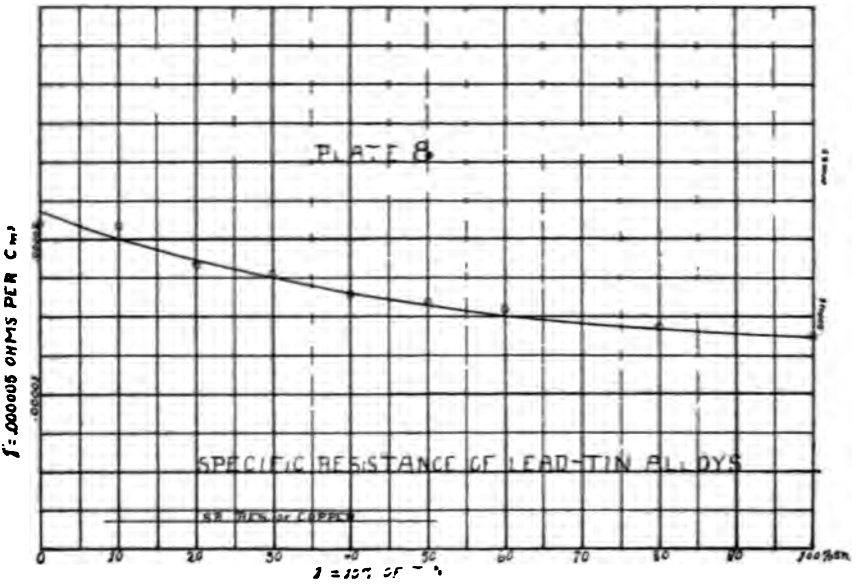
PLATE 7

TEST OF "BUTT" JOINTS ON NUMBER 8, BRASS AND COPPER WIRES. DIA. 0.128".

LIFE, IN DAYS, UNDER LOAD, AS DESIGNATED.

% TIN. 3850 %"		% TIN. 2900 %"		% TIN. 2100 %"		% TIN. 1400 %"		% TIN. 770 %"	
90B	0	90C	25	60B	5	90C	14	30C	89
90B	4	80B	39	60B	25	80B	84	20C	96
90C	44	80C	23	60B	25	60B	13	10B	
80C	4	70B	0	60B	35	60B	36	10C	68
80C	8	70C	22	60B	37	60C	14		
70C	8	70C	29	60C	1	60C	35		
60B	0	60B	9	60C	3	55B	78		610 %"
60B	3	60B	9	60C	3	30C		80C	
60B	4	60B	15	60C	3	20C	2	70C	
60B	5	60B	15	60C	7	20C	19	60C	
50B	10	60C	1	60C	9	10B	55	55C	
60B	14	60C	1	60C	10	10B	78	50C	
60C	1	60C	2	60C	10			44B	
60C	1	60C	3	60C	11		1000 %"		
60C	2	60C	3	60C	13	44B	7		
60C	3	60C	4	60C	35	40C	7		350 %"
60C	3	60C	5	60C	41	35B	7	40C	
60C	4	60C	5					35C	
60C	5	60C	10					30B	
60C	5							20B	
55B	2							10C	
65C	0								
70B	0								

PLATE 8.



ELECTRICAL RESISTANCE OF TIN-LEAD ALLOYS.

It was thought that the electrical resistance of tin-lead alloys might have some bearing upon their use in electrical construction. For purposes of comparison with other materials it was thought advisable to determine the specific resistances. Specific Resistance is defined as the resistance of a bar or rod having unit length and unit cross-section. The centimeter was the unit used. Specimens for this purpose were obtained by drawing wires having a diameter of 0.076 of an inch. The actual ohmic resistance of a length of 6 or 8 feet of this wire was determined by means of a box bridge. The specific resistance was then calculated from the equation,

$$R_s = \frac{R\ A}{L}$$

in which Rs is the specific resistance (in ohms per CM^3), R. is the resistance of a wire L cm. long, A is the cross-section in square centimeters. The results are given in plate 8 in the form of a curve, showing the relation between specific

resistance and percent of tin. For purposes of comparison the specific resistance of copper is also given. The variation in resistance, over the range of alloys suitable for solders was found to be so small as to have little weight in determining the alloy most suitable for electric construction.

CONCLUSIONS.

It is of interest to note that the method of making soldered joints, found to give the best methods, differ materially from the common one of "sweating" joints. The essential difference is, that in the method used in this study there was no pressure upon the solder at the moment of melting, while in the method of "sweating" the reverse is the case.

The results given in Plate 5 indicate that for tin-lead solders there is a definite relation between the load and life. The fatigue of soldered joints established as a result of these investigations suggest further research to determine the stress per square inch under which different solders will give permanent joints.

The results given in Plate 6 would seem to indicate that 60% solder was the most suitable for general work. For work requiring little mechanical strength, such as "sealing," etc., a lower percent of tin might be used. For work requiring great mechanical strength, and which is in sufficient quantity for the workman to acquire skill, a higher percent of tin might be used with profit.

IOWA PEAT.

G. B. ZANKE AND F. F. TAYLOR.*

The object of this thesis is the investigation of Iowa peat and the methods of preparing peat for the market. We have pursued our investigations along the following lines: first, the cost of preparing peat for the market; second, the extent and quality of peat bogs in Iowa; third, Iowa peat as compared with other peat on the market.

"Peat is a dark brown or black, often fibrous mass formed by the accumulation and decay of vegetable matter under water. It is the primary foundation of coal, next in age to lignite or brown coal, then bituminous or soft coal, and last anthracite or hard coal." (Julius Bordollo).

* Thesis is for B. M. E. Degree, Iowa State College, 1905.

The chemical composition and physical properties are given in the following table:

AUTHORITY.	Carbon....	Hydrogen...	Oxygen....	Nitrogen....	Sulphur....	Ash......	Sp. Gravity.
Percy's Metallurgy......	54.02	5.21	28.18	2.30	.56	9.27	.85
* M. Regnault..........	58.	6.	31.		0.	5 to 11	.4 to .5
* Clark...............	59.	6.	30.	1.25	0.	4.	
* Kent's Handbook, page 643							

Authorities disagree upon the sulphur content of peat. The majority claim that sulphur is not found in peat, but Mr. W. E. H. Carter, in the Bureau of Mines Report of Canada, 1903, finds sulphur in Ontario peat.

Peat, when first placed in the fire, burns with a short, blue flame which turns to an intense yellow glow, giving off an intense heat which may be easily and accurately controlled by adjusting the draft. Once well lighted, a peat fire will not go out until every atom is consumed. This is due to the fact that very little oxygen is necessary to sustain its combustion. Peat leaves no clinkers but leaves considerable ash depending upon the composition of the bog. When peat is burned in stoves or furnaces using wood or coal, which are not adapted for its combustion, there are heat losses due to unconsumed fuel falling through the grate, and to an over supply of oxygen. This can be remedied by using finer grates, or by covering the ordinary grates with clinkers or fine netting.

In burning peat under boilers designed for soft coal, the grate and fire wall at the back should be raised, and the spaces between the grate bars should be reduced one-half.

In the growing bog, raw peat contains from 85 to 90 per cent of water so intimately associated with the plant fibres that drainage will not reduce the water content to

less than about 85 per cent; while with 60 per cent, the peat feels and looks merely damp, and at 30 per cent, it is to all appearances dry. The real problem of peat fuel manufacture lies in removing the water; this solved, the other processes do not present insuperable difficulties. The cheapest way of preparing a fuel from raw peat is merely to cut it out of the bog and dry it in the air, when it is ready for burning. It is used in this form, to a large extent, for domestic purposes in Europe, but has no value as a marketable fuel for industrial purposes. The commercial product is known as machine peat, or peat briquettes, depending upon the method of preparation.

MACHINE PEAT.

Machine peat is the name commonly given to peat which is ground to a pulp while wet (sometimes with the addition of water), then cut or molded into blocks and dried with or without the addition of artificial heat. Machine peat is used in Germany, Austria, Denmark, Scotland, Sweden and Russia. In these countries it is not only used for domestic purposes, but also in manufacturing, metallurgical and other industrial operations.

There are in the United States, at the present time, a few plants engaged in the manufacture of Machine peat, one being at Lincoln Park, New Jersey.

Peat is cut from dry bogs either by men or by machinery. In either case it is conveyed to the peat machine by an endless belt, cart, or other conveying machinery.

Submerged peat may be recovered by dredging machines and conveyed to the peat machine by a pipe line or other conveyor. The work put on it by the centrifugal pump through which it passes will do much toward the necessary disintegration of the peat. Submerged peat bogs are sometimes drained by means of large ditches and then the peat is gathered as from a dry bog.

The peat press for producing machine peat is similar in principal to the pug-mill used in brick manufacture. It consists of sets of revolving cutters encased in a closely fitting cylinder which thoroughly cut, tear and mix the peat into a pulp, and a set of worm wheels, or horizontal screws which compress the peat as it is forced through a small opening onto boards which pass over rollers and a special mechanism for cutting to the length desired. After the

peat has gone through this machine, it has a dense, rubber-like structure and is compressed to two-thirds of its original volume. The compressed peat is now conveyed to the drying sheds. Part of the original water contents are lost in going through the press, and the evaporation of the balance is completed in summer, under favorable circumstances, in from fifteen to twenty days, at the end of which time the water content is about 20 per cent and the weight per cubic foot is about sixty pounds. By the above process the hydrocarbons, which are a natural binding material found in all peats, are broken up and diffused through the mass of fixed carbons binding them and putting them in a condition in which the water evaporates rapidly under ordinary conditions; the block then contracts into a more or less solid form. After the drying process is completed, the blocks will not absorb moisture and can be soaked without damage.

The approximate cost of a plant turning out twenty tons per ten hour day is $2500.00. It would employ about twelve men and the daily running expenses would be about $25.00, or the cost per ton would vary from about $.85 to $1.25, depending upon the size of the plant and the condition of the bog. The selling price of the finished product is generally about $3.00 per ton.

PEAT BRIQUETTES.

Peat briquettes are made by drying and grinding the raw peat and then compressing into dense briquettes. This kind of commercial peat is manufactured almost exclusively in Canada. The usual practice in making peat briquettes is to thoroughly drain the bog, then harrow the surface of the bog to a depth of one inch. This exposes the peat to the action of the wind and sun which dries down the water content to about 45 per cent. It is now gathered and conveyed to the plant. The quality of peat varies with the depth and in the above process particular attention must be paid to mix peats found at different depths to insure a uniform grade of briquettes. A mechanical excavator is sometimes used which travels slowly over the bog digging the peat and throwing it by means of a paddle which revolves at a high speed thirty or forty feet over the surface of the bog.

The plant proper consists of a disintegrator, dryer and press. The disintegrator usually consists of a cylinder shaped casing in which, revolving at a high speed, are knives

and arms which break up and tear the peat into fine particles. The dryer consists of a revolving cylindrical, steel shell surrounded by a fire. Moist peat is fed in at the upper end where the fire is the hottest and is dried in passing through to about 16 per cent of moisture. The heat within the cylinder is over 212° F. to evaporate the moisture in the peat. In action, it is somewhat like a cement kiln, except that the greatest heat is on the outside. The peat press takes the dried peat and compresses it under a pressure of about twelve tons per square inch into the finished product. There are two different kinds of peat presses in operation in Canada, the Dobson and the Dickinson.

It has been found that a cylindrical briquette about two inches long and about the same diameter gives the best combustion and is also a convenient form for manufacture.

In making peat briquettes, it is possible to take raw peat from the bog one day and have it converted into the finished product by the next. Experiment has shown that not more than 15 per cent of moisture can be removed from raw peat by pressure alone.

A complete plant capable of producing ten tons of briquettes per ten hour day will cost about $10,000.00 The average cost of producing one ton of peat briquettes is about $1.25.

PEAT GAS.

Gas made from peat has long been used in the iron and steel industries of Sweden, in which country it is preferred to coal gas because of its freedom from sulphur and phosphorus. It has the same advantages over peat fuel that other gases have over the solid fuel from which they are made. As yet, very little has been done in America in the generation of peat gas outside of experimental work. Results show that a good gas can be economically made from peat containing up to 30 per cent of moisture.

Mr. Carter, in the "Ontario Bureau of Mines," 1903, says, "The most important reason why peat gas can be more profitably and extensively employed than peat in large industrial works lies in the fact that by locating a large, central power station at a suitable bog the cheapest kind of peat, namely, cut peat, satisfies all requirements, and the gas may then be piped for distribution, or, if the place of consumption be at a great distance, it may be converted at the bog into electrical energy."

TABLE NO. I.

SAMPLE NO.	I WATER GAS—PER CENT											II PRODUCER GAS—PER CENT					MIXTURE I AND II—PER CENT				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Benzine and Benzoles...	.4	.6	.7	.3	.3	.3	.5	.4	.8	.4	.8	1.8	1.2	1.6	1.0	1.2	.5	.5	.6	.7	.8
Illuminant..............	.2	.2	.2	.3	.2	.2	.4	.3	.2	.2	.2	.2	2.	.4	.4	.6	.2	.2	.8	.6	.4
Carbon Monoxide........	17.8	17.8	17.4	17.3	17.2	17.4	17.2	17.2	16.8	16.8	16 5	13 6	13.6	7.8	7.8	11.6	15.	15.4	15.25	16.6	16.2
Hydrogen..............	14.9	12.1	13.02	12.87	12.98	12.5	13.6	12.5	12.43	12.34	12.58	8.56	8.99	4.19	4.87	3.13	12.5	12.6	11.8	12.2	12.3
Methane................	4 15	4.26	5.48	6.11	5.9	5.86	5.2	5.86	6.17	6 17	6.29	7.14	7.49	5 24	4.68	4 68	3.9	.4	4.2	4.1	4.6
Oxygen.................	0	0	0	0	.2	0	0	.2	0	.2	.2	.6	.6	.4	.4	.2	.6	.5	.85	0	.4
Carbon Dioxide..........	11.	10.8	10.3	10.7	10.7	10.7	9.5	10.5	10.8	11.6	9.7	12.4	12.	11.2	11.8	15.2	13 3	13.2	12.8	12.1	12.2
Nitrogen................	51.55	54.24	52.9	52.42	53.28	53.04	52.6	53.04	52.8	52.69	53.73	55.7	53.92	69.17	68.48	63.39	.54	53.6	54.2	53.7	53.1
B. T. U. PER CUBIC FOOT					137.72 146.89 146.89 137.92 157.0								109.2 109.8 109.8 109.8					136.8 135.65 136.8 136.7			
Average..............	....				145.3								109.6					136.4			

Table No. I is taken from the Bureau of Mines Report, 1903, and gives the composition of different gases made from cut peat in a Merrifield gas generator at Toronto Junction.

Table No. II is taken from Kent for the purpose of comparison. The composition of the coal from which the gas was made is as follows: Water 1.26%, Volatile Matter 36.22%, Fixed Carbon 57.98%, Sulphur, .7%, Ash 3.78%.

TABLE NO. II.*

Analysis by Vol.	Per C'nt.	Cubic Feet	B. T. U.	B.T.U. Per Cubic Foot
Carbon Monoxide	25.3	33,213.84		
Hydrogen	9.2	12,077.76		
Methane	3.1	4,069.68		
Ethylene	0.8	1,050.24		
Carbon Dioxide	3.4	4,463.52		
Nitrogen (By Diff.)	58.2	76,404.96		
	100.0	131,280.00	20,311,162	155.0

The two tables show that peat gas compares very favorably with coal gas. A plant producing not less than 20,000 cubic feet of gas per hour will cost, approximately, $5,000.00.

BY-PRODUCTS.

With suitable apparatus, by-products of peat can be saved. Some of the by-products, besides gas, are Ammonia, Acetic Acid, Creosote, Carbolic Acid, Pitch, and Coke. Some of the uses to which peat can be put, besides fuel, are the following:

Non-conductor—As a non-conductor, peat is used in ice-houses and as a pipe covering.

Packing Material—Coarse peat is used in place of straw as a packing material for glass and chinaware.

Disinfectant—Powdered peat is a cheap, efficient and odorless disinfectant for rooms, closets and stables because of its great absorbing powers. In some parts of Germany it is used for this purpose on the streets.

* Kent's Mechanical Engineers' Pocket Book, 3rd Ed., p. 649.

PEAT AS FOUND IN IOWA.

Peat is found in Iowa in that portion of the State which is covered by the Wisconsin Drift Area. In determining the location and extent of the peat bogs in Iowa we received assistance from the Division of Agriculture, Iowa State College, whose statics seem to show that there are large and numerous peat bogs throughout this portion.

In the spring of 1905, we visited several of these places and in most instances found that while there was peat in them it was not very thick and had put little fuel value. However, there are several peat bogs of considerable thickness. There are two large bogs near Dows, one of 100 acres, and the other of 200 acres. The latter, which is being developed, will average twelve feet in thickness.

Mr. T. H. Main, of Omaha, Nebraska, who has investigated the peat fuels in Iowa, says that Cairo Lake, Wall Lake and Iowa Lake have about 860 acres of about the same depth.

The geological survey of Iowa have not as yet investigated the peat bogs in Iowa and until they do this no accurate information of the peat bogs can be obtained.

It is claimed that peat bogs, or sloughs, can be converted into good corn land in about three years, so it is only the large bogs that can be profitably worked for fuel.

In testing the different samples of peat we determined the B. T. U.'s per pound, or the heat value, and the per cent of ash.

The B. T. U.'s were determined by the Parr Standard Calorimeter in which the sample of fuel is actually burned and the heat of the combustion is measured. The calorimeter consists of a combustion chamber and a calorimeter bath, the latter consisting of a vessel surrounding the combustion chamber and containing a known quantity of water. The elevation of the temperature of the water when accurately measured and multiplied by a suitable constant peculiar to the apparatus, determines the heating power of the fuel. Before testing, the peat was thoroughly dried in an oven, for one hour, during which a temperature of about 220° was maintained.

In the ash test about two or three grammes of the oven-dried peat was put into a crucible which was kept over a Bunsen flame until the combustion was completed. The weight of the ash was then determined, and the ratio of the weight of the ash to the weight of the dry peat gave the percent of ash.

Table Number III, taken from the Bureau of Mines, Ontario, Canada, 1903, gives a comparison of peat in its different forms to anthracite and bituminous coals. To obtain the same heating value as one ton of anthracite coal 4080 pounds of peat briquettes or 4900 pounds of machine peat would have to be used; and to obtain the same heating value as one ton of bituminous coal 3450 pounds of peat briquettes or 3942 pounds of machine peat would have to be used.

Table Number IV gives results of tests made on commercial peat found outside of Iowa. The peat from Lincoln Park, New Jersey, was machine peat, and that from Ontario, Canada, and White Water, Wisconsin, were peat briquettes.

Table Number V gives the results of tests of Iowa peat. These samples were taken directly from the bog and were not put through any of the processes gone through in making commercial peat.

TABLE NO. III.

MATERIAL	Weight per cu. ft. as Piled	Relative Weight for Same Heat Value	Relative Bulk for Same Heat Value	Specific Gravity
Cut Peat	13 Lbs.	2.99	14.36	.50
Machine Peat	21 "	2.45	2.56	.95
Peat Briquettes	56 "	2.04	2.14	1.12
Bituminous Coal	60 "	1.36	1.43	1.30
Anthracite Coal	63 "	1.	1.	1.45

TABLE NO. IV.

Location of Peat Bogs	B. T. U.	Ash Per Cent.
Lincoln Park, N. J.	9875	14.0
Ontario, Canada	8800	17.5
White Water, Wisconsin	9200	12.0

TABLE NO. V.

Location of Bog	Depth of Sample	B.T.U.	Ash %
Dows	Surface	6600	36.
Dows	4 Feet from Top	8500	18.8
Dows	6 " " "	6375	47.5
Dows	9 " " "	5850	49.
Algona, Bog I.	3 " " "	6900	36.5
Algona, Bog II.	2 " " "	7100	31.5
Ames	3 " " "	7000	35.
Burt	4 " " "	5500	50.
LuVerne	3 " " "	5000	55.

The bog at Dows consists of 200 acres and has an average depth of twelve feet. Four samples were taken at the depths indicated. The sample taken at four feet shows up best, but the one at six feet should have shown up as well or better but for the large amount of sand found in it. This peat was tested for sulphur, but was found to be free from sulphur.

The other samples were taken from bogs averaging about 30 acres and having a depth of four or five feet. The fuel value was found to be low and the percentage of ash high. It is this kind of bogs that is being rapidly turned into good corn land by the Agricultural Department.

We were unable to obtain samples from the large bogs in Iowa, but the peat from Dows has, according to Mr. T. H. Main, the same heating value as that from Cairo, Wall and Iowa Lakes.

The peat from the smaller bogs in Iowa does not show up well with commercial peat on the market, being low in fuel value and high in ash but the peat from Dows compares very favorably with that on the market.

Any one thinking of developing a peat bog should have samples of it taken from different parts of the bog and at different depths tested for B. T. U. and ash. The B. T. U.'s should not be much below 8000 and the ash should not be over 20 per cent. He should also have suitable and convenient means of draining the bog.

NOTE. Since the preparation of the above, Bulletin No. 2, Iowa Geological Survey, has been published. (Fall, 1905.) This publication contains much valuable information on the subject of the peat deposits of Iowa and also some general information on the subject of the manufacture of peat into marketable fuel in this and other countries. This Bulletin was prepared by Mr. F. H. Wilder, State Geologist, and Mr. T. E. Savage, Assistant State Geologist.

The following from Bulletin No. 2, U. S. Geological Survey, is also of interest.

"The peat from one locality (Massachusetts) was collected, cut into small fragments, pressed into crude bricks, approximately 3 by 6 by 1½ inches in size, and the moisture reduced by air drying from 85 to 45 or 50 per cent. In this form, the peat was fed into the producer at the rate of 600 to 750 pounds per hour. The results of the test were eminently satisfactory. The peat burned freely, evenly and completely. The gas had a fuel efficiency of 166 British thermal units per cubic foot of gas, as compared with 142 to 159 British thermal units per cubic foot of gas made from bituminous coal. The engine was run continuously during this test under full load. This same peat, cut into small fragments, but in loose and wet condition (containing 80 to 85 per cent of moisture), did not burn satisfactorily in the producer, and attempts to dry this loose peat in the Bartlett direct-heat rotating dryer were unsatisfactory, owing, in part, probably, to lack of time for readjusting the equipment to suit the unusual conditions imposed on it in handling the peat.

"Shipments of peat from a number of other localities will be tested during 1906 and efforts will be made to develop better facilities for handling the unbriquetted material.

MASSACHUSETTS PEAT.

"Peat Briquettes from bog near Halifax, Plymouth County, Mass. They were furnished by Prof. C. L. Norton, of the Massachusetts Institute of Technology, Boston, Mass., and shipped under the supervision of J. S. Burrows.

"This sample consisted of a small amount (less than 5 tons) of peat which had been macerated and pressed into bricks and then dried, and it was impossible to run a test of sufficient length to eliminate the factor of uncertainty. It was demonstrated, however, that a satisfactory gas could be obtained, and no trouble was experienced in manipulating the fuel bed or in maintaining the load, but owing to the small supply of peat it was necessary to make the foundation of the fuel bed out of another fuel, — Illinois coal. Considering this fact, and that the amount of peat furnished made it possible to conduct a test of only nine hour's duration it is possible that the results as given below are somewhat erroneous. The figures are given, however, for what they are worth, as they furnish an approximate idea of the possibilities of peat fuel in the gas producer, although they cannot be regarded as official results. It is impossible to tell what portion of the gas was due to the Illinois coal and what portion to the peat alone.

The results of the test of the Massachusetts peat were as follows:

Producer — Gas Test.
Peat.

Average electrical horsepower..................	200.0
Average B. T. U. gas, per cubic foot..........	166.6
Total peat fired........................pounds	6,480

Peat Consumed in Producer.
(Pounds per horsepower per hour.)

	Test 97		
	Peat as Fired	Dry Peat	Com-b'stible
Per electrical horsepower:			
Available for outside purposes	3.77	1.89	1.44
Developed at switch board	3.60	1.81	1.38
Per brake horsepower:			
Available for outside purposes			
Developed at engine			

Analyses.

	Test 97		Test 97
PEAT		GAS BY VOLUME	
Moisture	49.80	Carbon Dioxide (CO_2)	10.5
Volatile Matter	27.27	Carbon Monoxide (CO)	22.5
Fixed Carbon	10.88	Hydrogen (H_2)	14.9
Ash	12.05	Methane (CH_4)	2.1
		Nitrogen (N_2)	51.0
	100.00		100.0
Sulphur	0.34		

"In connection with this test of a small quantity of Massachusetts peat it is deemed advisable to refer to a more elaborate test of peat bricks obtained from Florida, the results of which test have been obtained in time to be mentioned here, although the test was run subsequent to the date covered by the body of the report. In the producer-gas test of the Florida peat the producer was maintained in operation for fifty hours, and no difficulty whatever was experienced either in maintaining the load or in handling the fuel bed. The peat was furnished by the Orlando Water and Light Company and was secured from a bog near the city of Orlando, Orange County, Fla.

"In starting the producer test the fuel bed was built up entirely of the Florida peat, and the usual preliminary run was conducted before the official test began. The total amount of peat consumed in the producer in the fifty hour run was 29,250 pounds, or 585 pounds per hour. The average calorific value of the gas produced was 175 British thermal units per cubic foot. During the entire run the average electrical horsepower developed at the switch board was 205. The amount of peat used per electrical horsepower per hour available for outside purposes, including the estimated quantity required for the generation of the steam used in the operation of the producer, was 3.16 pounds, while 2.69 pounds were required per brake horsepower at the gas engine, available for outside purposes.

"It should be stated that the peat bricks had been dried and that the moisture content of those used averaged 21 per cent. The gas was particularly rich in hydrogen, running 18.5 per cent, and comparatively low in nitrogen (45.5 per cent).

"As there was a small supply of peat bricks left after the completion of the gas-producer tests, a short run of a little over four hours was made in the boilers. This was not sufficiently long to make any definite conclusions possible, but the results obtained were exceedingly satisfactory so far as they went. No difficulty was encountered in keeping the boiler up to its rated capacity, and, in fact, during the four hours' run the percentage of rated horsepower of the boiler developed was 113.2. The amount of peat burned per indicated horsepower at the steam engine was 5.66 pounds, and per electrical horsepower hour at the switchboard was 6.98 pounds. The calorific value of the peat as used was 10,082 British thermal unites per pound. The principal difficulty in the utilization of peat under boilers appears in the frequency with which it is necessary to fire. On account of the lightness of the material and also on account of its rapid combustion the fireman was kept at work almost constantly during the test."

While no money has been spared to reduce grades, build tunnels, shorten the mileage and make the road-bed more substantial, yet, with all this and the heavier steel in use today, the track has not improved in proportion to the increased operating conditions. Thus the modern locomotive necessitates finer designing as the speed, size and pressure carried have increased, and it must operate with decreased internal stresses and reduced injury to track.

With the demand for increased speed and the desire for heavy trains it was found impossible to make the small boiler generate sufficient steam for large cylinders operating at even a moderate degree of speed. Accordingly the large boiler came into use and this in turn necessitated the use of trailers beneath the fire-box. The great increase in size of boiler is the principal question in the design of the modern locomotive and it has caused locomotive builders to reconsider the principles of design. Thus the generation of steam is the fundamental question and upon this depends the power of the locomotive, and to gain this, economy is often sacrificed. The following abstracts take this up in a very thorough manner and are considered very good authority.

An abstract from a paper on "Some Factors Affecting the Power of Locomotives," read before the New England Railroad Club, December, 1901, by Prof. W. F. M. Goss of Purdue University:

"An appreciation of the importance of the mean effective pressure as a factor in the power of a locomotive has often led to the adoption of devices which appear to be advantageous, but which in fact are not so. Thus, a change in the proportions or setting of slide valves may result in an increased mean effective pressure for a given position of the reverse lever, and the argument is advanced that the power has been increased. Again modifications in valve gear may result in 'filling out the card;' that is, straightening the steam line, in squaring the corners and in giving withal an increased mean effective pressure, and because the mean effective pressure is increased, it is often argued that the power is increased. In fact, any change which may result in an enlarged card for a given position of the reverse lever is likely to be brought forward as evidence of an increased power. But such evidence is not conclusive. A detail which accomplishes no more than an increase of the mean effective pressure for a given position of the reverse lever, accomplishes nothing which might not have been more easily attained by its omission, and by merely advancing the reverse lever on its quadrant. For speeds which are sufficiently high to permit the adhesion of the drivers to absorb the full power of the cylinders, the maximum

power depends upon the boiler capacity and upon the efficiency of the engines, and upon nothing else. Whatever may contribute to enlarging the steam capacity of the boiler, contributes to an increase of power, and whatever operates to reduce the consumption of steam per unit of power developed, will extend the limit of maximum power. The real test, therefore, which should be applied to every detail which is assumed to increase the cylinder power of a locomotive, concerns its effect upon the steam consumption of the engine. Will its use produce a horse power upon the expenditure of less steam than the device which it supersedes? If it will, then, when the boiler is supplying all the steam it can make, it will permit the cylinders to deliver more power than they were able to do without it. If it does not increase the efficiency of the cylinder action, it can not really increase the power.

"This suggests the inquiry as to whether the distribution of steam in the cylinders of simple engines is satisfactory; whether, for example, we ought to persist in efforts to secure square-cornered cards. The reply is that in most cases where the gear is sufficiently heavy and stiff to do the work for which it is designed, the distribution as obtained from present gears is satisfactory. The typical locomotive card, displaying the wire drawing action throughout the cycle, which, especially at high speed, is strongly marked, is, after all, a card of high efficiency. The steam consumption of the locomotive is less than that of most other forms of high-speed steam engines employing atmosphere exhaust. Even when the speed is increased to limits which far outstrip those common to stationary types of engines, its work is to be regarded as highly efficient. So well do the better class of valve gears which are now in common use perform their work, that any one who attempts to increase the power of a modern locomotive by improving its steam distribution, will find but a narrow margin upon which to work. On the other hand, it should be equally evident that the adoption of compound cylinders, or of provisions for the use of superheated steam, are matters which, if well worked out in detail, can not fail to effect the economy in the use of steam, and, as a consequence, to raise the limit of maximum power."

F. F. Gains in an article to the editor of the Railroad Gazette says, "the maximum power, as effected by the boiler capacity, seems to be the line for improvement from which good results can confidently be expected." From his experience, he thinks, too much time has been spent on valve motions in an effort to get a theoretical indicator card when more tangible results could have been obtained if the same amount of time had been spent in studying steam generation.

"The variations between the best and the worst types of valve motions, as effecting the power and economy of an engine, are so small compared to the efficiency of the boiler, as to render obvious the advisability of using available time and effort for the improvement of the generator rather than the motor. This is not to be construed as meaning that we have reached perfection mechanically, as either the piston or present slide valve are a good ways from that desirable condition. While the steam consumption of the locomotive compares favorably with the stationary engine under the same conditions, how about the generation? The discrepancy of this item is such, that it should entice further effort to lessen it. It is only recently that grate surfaces have been of sufficient area to allow of a reasonable consumption of coal per square foot of grate per hour. In this respect our best practice is only equivalent to the worst French practice." He spoke of the investigations being carried on, at that time (1902), in Europe for increasing the power and economy of the locomotive. These investigations were with superheated steam, with decided economy, but with trouble from leaky joints which he termed mechanical difficulties that should be overcome. There are other reasons, other than that of increasing the limit of maximum power, for a higher economy in the locomotive. The firing of the locomotive today has almost reached the limit of one man's capacity. By increasing the economy a larger amount of work is possible without increasing the amount of coal handled. The economy in locomotive operation has received more attention in Europe. This is due to a corresponding higher value of coal and as railroading is not as strenuous it allows of more freedom in designing. The following articles will give a general idea of the cost of fuel as compared with other expenses.

Mr. A. D. Parker, general auditor, Colorado & Southern railway, says: "The fuel amounts to the enormous figure of 36 per cent of the total expenses of locomotive operation, including the renewals and repairs. Fuel is the largest factor, when taken by itself, in railroad operation, and in its consumption there are great opportunities for both loss and gain. The cost of fuel amounts to 12¾ per cent of the total cost of operating a modern railroad."

Mr. G. R. Henderson in a paper to the American Engineer and Railroad Journal, on the cost: "The fuel bills of a railway constitute about 10 per cent of the total expenses of operation, or from 30 per cent to 40 per cent of the actual cost of running the locomotive. On important systems the gross amount of coal burned assumes a very large figure, running into millions of tons. Each engine will probably consume $5,000 worth of coal

in a year on the average, so that for 1,000 locomotives the annual coal bill would approximate $5,000,000."

Improvements that give an increased economy will be taken up in detail, that is, those that have proven beyond a doubt that the increase in economy is greater than the corresponding increase in cost of construction, operation and maintenance. The locomotives of the continent, and it is there that many of the improvements have developed, are much more complicated in design. The general differences in the design of the various parts will be more noticeable when the different improvements are taken up in detail.

"The simplest machine is not always the one which has the fewest parts."—Goss.

VALVES AND VALVE GEARS.

The Stephenson valve gear derives its motion from two independent eccentrics and, as it is commonly used, is connected to slide valves of either the flat or piston type. Many other types of valves and valve gears have been introduced and experimented with but none, except the Walschaert, have ever been adopted to any great extent in locomotive operation. The motion of the latter is derived both from the crosshead and an eccentric crank from the driving axle. The crosshead connection imparts the lap and lead at the extremities of the stroke. The eccentric crank is then in its middle position and its fastest movement is used to give the valve a quick opening.

"The Marshall valve gear designed by James T. Marshall, of the Boyne Engine Works, Leeds, combines several features of the above valve gears. Two eccentrics are used for actuating the gear of each cylinder. One eccentric is keyed upon the crank shaft directly opposite the crank. By means of the strap and forked eccentric rod connected to the two swinging rocking arms which carry the trunnions it controls the lap and lead only of one valve. The second eccentric is keyed upon the shaft at about 90 degrees in front of the crank, and is connected by a strap and rod to a bell-crank lever rocking upon a fixed shaft supported in brackets attached to the engine frame plates. The other bell-crank lever is connected by a coupling link to an arm which is solid with the trunnion bracket, fixed to the radius link. The radius rod, which is coupled to the slot link at one end, and at the opposite end to the valve spindle plunger. The differential motion of the gear causes the valve to open and close the steam port quickly and slow travel when the port is fully open. The Great Southern and Western Railway, Ireland, has conducted important tests with a locomotive equipped with the Marshall valve gear. During 11 months the engine ran over 50,000 miles

without trouble or delay of any kind."—Nov. 3, 1905, "Engineer."

The Walschaert gear was invented by Egide Walschaert, master mechanic of the Belgium State Railways, about the year 1844, and for many years it has been commonly employed upon the locomotives throughout foreign countries, 90 per cent of the main line locomotives in continental Europe being equipped with this gear. This valve gear is now being rapidly introduced into this country to meet conditions imposed by the development of the locomotive. The gear also gives a constant lead but all motive power men do not agree that this is an advantage. On large locomotives the Walschaert valve gear has the following advantages, over the Stephenson link motion:

(1) Walschaert gear transmits the moving force to the valve in very nearly straight lines and the springing and yielding of the Stephenson motion is avoided.

(2) The valve gear is accessible permitting inspection, lubrication and repairs. It is also more liable to receive injuries but with inside cylinders and cranks there is litle room for eccentrics and links.

(3) It facilitates bracing the frames laterally.

(4) Stephenson links are operated by two eccentrics and move through wider angles. The testing plant shows smoother operation in favor of the Walschaert due to the lessened angularity of the links.

(5) The Stephenson eccentrics, being larger, make lubrication more difficult due to the high surface velocities and there is a greater tendency to uneven wear.

"In reference to the Walschaert valve gear, engine No. 912 has now a total of 1-16 inch lost motion in the valves. This is the total lost motion in the whole motion work. This engine has made approximately 39,000 miles, and engine No. 5924 (with link motion), examined the same date, 5-16 inch lost motion in the valve stem, and has made approximately 32,000 miles. This seems to be very much in favor of the Walschaert motion." Mr. H. F. Ball, Supt. of M. P., L. S. & M. S. R'y.

"In the above engine (2-8-0 type No. 912) the total weight of the parts, excluding valves, is 1252 pounds. The weight of the corresponding parts of a recently constructed 20x28 inch engine (4-6-0) with Stephenson link motion, is 2,734 pounds." Am. Eng. & R. R. Jr.

The increased weight of the Stephenson motion imposes a heavy load on the eccentrics. The inertia of the reciprocating parts, being reversed twice for every revolution, causes the eccentrics and straps to heat and interferes with permanent adjustment. The result is a distorted steam distribution. While

the Walschaert gear, as ordinarily constructed, is not symmetrical in a vertical plane, and there is a tendency to lateral bending and unequal wear, yet, these objections may be avoided if special attention is given to the design.

Three new types of valves and valve gears designed in America will be discussed. While many have been designed to improve the steam distribution, few have ever remained in service for any length of time. In each of the three designs the Stephenson link motion is employed but in each case some form of mechanism is added to improve the efficiency of the steam distribution.

While the ordinary Stephenson valve gear operating the common piston or slide valve is very efficient, as compared with other forms of high speed engines, operating under similar conditions in stationary practice, there is still room for improvement as explained under "maximum power." They are necessarily more complicated than the ordinary valves and gears, but that is not the important question, is their construction reliable and durable? What is the wear and tear on machinery as compared with locomotives, equipped with flat or piston slide valves, in ordinary service? How does the cost and maintenance of the former and latter systems compare? The above will be answered as far as reliable information is available.

The question of cylinder clearance and compression will not be discussed here, as space does not permit, but the reader is referred to the experiments carried on during the last thirty years by Prof. Robert H. Smith. Mr. D. K. Clark worked along this line but with one intial pressure whereas Prof. Smith has worked out general calculations.

THE YOUNG SYSTEM.

This is an application of the Corliss system to locomotives. Mr. O. W. Young invented the system and it was first applied to two passenger locomotives on the Chicago & Northwestern R'y. Each cylinder has two oscillating horizontal valves, mounted in cylindrical chambers above the cylinder. Each valve controls the steam admission and exhaust at one end of the cylinder. The weight of the valve is carried by end bearings and packing strips divide the chamber into steam and exhaust compartments, and four strips at each end isolate the exhaust compartment, live steam being allowed to pass around the ends of the valve.

The valve rod from the rocker arm is attached to a T shaped wrist plate, from which the valves are operated by short connecting links, attached to arms on the valve stems. The lead is normally 1-32 inch but can be varied by operating the reverse lever.

The above description was taken from the Eng. News and also the following:

"According to a statement issued by Mr. Robert Quayle, superintendent of Motive Power and Machinery of the Chicago & Northwestern Ry., the cost of cylinders and valves, and including the necessary changes in the valve motion, should not exceed that for an ordinary engine by more than 30 per cent, or $150 per engine if the design is made standard. The first engine was equipped in 1901, and the second in September, 1903, the latter being used in various kinds of service and by various crews. By October, 1904, it had made about 90,000 miles, and had demonstrated that the wear and tear on machinery was very much less than on engines with flat or piston slide valves. The reason for this is that the crank effort at the most effective points is higher and more uniform with the new valve and gear, and this also results in a greater turning effort when starting, thus reducing the slipping of wheels."

One of the above locomotives ran 133,000 miles before shopping, during which time the tires were not turned, and a 1-16 inch cut trued them up when the engine finally went to the shop.

"The Delaware & Hudson has in service two ten-wheeled (4-6-0) freight locomotives equipped with the Young valves and gear, which has been running since November 21 and December 24 respectively. The performance of these engines up to February had been most satisfactory." R. R. Gaz.

THE ALLFREE-HUBBELL SYSTEM.

"In this system the rock shaft is driven in the usual way by a rod from the link block. The valve rod attachment instead of being a simple pin, is practically a crank shaft of small throw: the shaft is 1¾ inches in diameter, and the middle portion, (to which the valve rod is attached), is not concentric with the ends. The ends are carried in the two arms of the rock shaft, and one of them projects far enough to carry a small pinion. Pivoted near the guide yoke is a vertical lever, the long lower end of which is connected by a rod to the cross-head, while the upper end is connected by a rod to a segmental rack which is journaled on the rock shaft and gears with the pinion.

"The purpose of the sector and pinion gear is simply to time the events of the valve and then to hold their position while the eccentrics and link move the valve. It accelerates and increases the valve travel at all times of port opening; it also retards and decreases the travel during the period between the cut-off and the exhaust opening, and between the opening and closing of the exhaust ports." Eng. News, May 4, 1905.

In the above system a special form of valve and cylinder

construction is used. The steam distribution to the cylinder is controlled by a long slide valve with flat surface, but partly cylindrical shape, and supported by riding shoes. These valves weigh about 100 pounds and have 200 square inches riding surface, as against an American or Richardson Balanced valve weighing considerably more and with a decrease of almost 40 per cent in riding surface. The cylinder ports are very near the end of the cylinder and long passages are avoided. The inside admission type of valve is used and the exhaust steam is conducted from the ends of the exhaust chest downward behind the cylinder heads to the exhaust nozzle. Thus the exhaust steam does not come in contact with the cylinder walls or with the valve chamber which contains the live steam. This form of valve and cylinder construction makes it possible to reduce the cylinder clearance from 8 per cent to $2\frac{1}{2}$ per cent and at the same time about one-third of the cylinder is jacketed by live steam. A number of locomotives equipped with the Allfree-Hubbell system have been used for both freight and passenger traffic and no trouble has resulted from the reduced clearance not giving sufficient compression to cushion the hammer blow of the mass retardation at the end of the stroke.

The latter system has been adopted to a much greater extent than either of the other two recent designs. Locomotives equipped with this system are in regular service on the Central Railroad of New Jersey, the Pittsburg & Lake Erie, the Pere Marquette Ry., the Chicago Rock Island & Pacific Ry., the Wabash Ry., the Kansas City, Mexico & Orient Ry., and the Oregon Short Line. Several engines so equipped have been in service over two years and they have proven satisfactory, and railway men speak very highly of the advantages gained and low cost of repairs.

THE HABERKORN SYSTEM.

The Haberkorn Engine Company, Fort Wayne, Ind., have applied their valve mechanism to locomotives. A locomotive on the Wabash was equipped with this mechanism during 1903 and in the early part of 1905 the engine was shopped for general repairs. Although the parts were very light, the valve showed very little wear. The locomotive was reported to have used less water and coal than similar locomotives with ordinary valves and gear, and the tires were evenly worn. The writer has been unable to ascertain if any other locomotives have been equipped with this system.

Each cylinder is fitted with two piston slide valves, the upper one being the cut-off, and the lower the main or distribution valve. The two valves receive their motion from opposite eccentrics.

COMPOUND LOCOMOTIVES.

The compound locomotive produces about 25 per cent more I. H. P. than an ordinary single expansion engine operating under similar conditions. The saving in coal, of the compounds over the simple engines, in the tests conducted at the Louisiana Purchase Exposition, varied from 10 per cent to 40 per cent, but it must be remembered that these tests were favorable to the compound. The above locomotives consumed from 18.6 to 27 pounds of saturated steam per I. H. P. hour. Aided by a superheater it was reduced, the minimum being 16.6 pounds of superheated steam per hour. In the latter case the coal per I. H. P. per hr. was 2.38 pounds, the equivalent evaporation per pound of dry coal was 9.11. Practice has shown that the increased weight due to compounding gives better results than if a like amount were used to increase the boiler capacity.

The following gives some idea of the general use of compounds abroad:

In a paper on "Locomotives Exhibited at the Paris Exposition of 1900," presented by Mr. Storm Bull at the Milwaukee meeting (May, 1901), of the A. S. M. E., he said, in part:

"Another feature which one could not help notice at once was that fully one-half of all the locomotives exhibited were compound. It is probably also true that about half of all the engines built now on the continent are compounds, so that the exhibition gave a true picture of this industry. In this respect I think that they are ahead of us, as, although some roads in this county are getting quite a good many compounds, in the majority of cases it seems that an ultra-conservatism keeps us back. This statement assumes, of course, that the compound is an advance over the single expansion one, and this opinion is now backed by nearly all competent authorities in Europe, possibly outside of Great Britain. The statement ought, however, to be qualified to this extent, at any rate, that it does not apply to all kinds of service, but certainly to all through trains. There were compound engines shown of every conceivable design and combination: with two, three, and four cylinders, and these arranged like the Vauclain, or two inside and the others outside the frame; or again, as on a Russian engine, tandem fashion outside the frame. On the French compounds the de Glehn system seemed almost universally in use. This system was, as is well known, first adopted by the Northern Railways of France, but has since been introduced into all of the French railway companies, including those belonging to the state, and it is the universal opinion that these engines are doing excellent service. Engines of this class are now pulling the fastest long-distance train in the world--the fast express between Paris and Bayonne, in southern

France. As a matter of fact, it may be stated that nearly all the fast trains in France are at the present time being pulled by compound engines. The objection which has been advanced by so many in this country against the compound locomotive—that it costs so much to keep it in repair—has certainly been overcome by the continental designs, as is proven by the records of these engines during the last few years."

THE MELLIN COMPOUND.

In September, 1894, the Richmond Locomotive and Machine Works built an engine on the Mellin principle. This compound, known as the Mellin or Richmond compound, was one of the first successful two-cylinder compounds and because of its wide wanderings it was known as the "Tramp" locomotive. It was loaned gratuitously, to any road desiring to investigate the relative merits of the compound on one condition, the results, whether favorable to the compound or not were to be made public. In every case the results favored the compound and the general average showed a saving in coal of 26.1 per cent and of water approximately 16 per cent.

Notwithstanding the advantages shown by the Mellin compound it was never very popular and during the past year or so fewer have been put into service than in former times. On a few roads the Mellin compound has undoubtedly come to stay. The Michigan Central, Grand Trunk and Soo Line, many of whose freight engines are of this type, are its strongest advocates and it has long been the standard engine on the State Railways of Sweden. In recent tests, carried on by the latter roads, it proved its superiority over all comers.

The high-pressure cylinder is placed on the left side of the engine and the low-pressure cylinder on the right side. The reducing valve automatically closes, and the intercepting valve opens, after the exhaust of the high-pressure cylinder has accumulated. The emergency exhaust of the high-pressure cylinder may be opened and by a three-way cock the engine, if desired, may be worked simple for any period of time.

The recent two-cylinder compound built for the Central Vermont and Grand Trunk do not justify the belief that the capacity for growth of the two-cylinder compound is limited by the size of the low-pressure cylinder. The Soo Line has several new consolidated freight engines of this type also and one is equipped with a Cole superheater which will be taken up under the superheater compounds.

ARTICULATED COMPOUNDS.

In the ordinary type of locomotives many restrictions are

imposed, especially on steep grades, where a large hauling capacity is necessary. The weight per running foot is usually limited and to secure an increased total weight and power, it becomes necessary to lengthen the rigid wheel base and at the same time the total wheel base. In doing this several features enter which are detrimental to both the engine and the track and a corresponding wear and tear is the result. There is also a greater friction in passing through curves, and a portion of the weight being carried by the trucks is not available for traction.

To remedy these evils, the introduction of two separate engines under the same boiler, was resorted too. In England the "Fairlie" engine was introduced, both engines being mounted on swivel trucks. In Austria this design was improved by making one truck rigid and the other one swiveling. This engine was improved by Mallet, the French locomotive designer, and the result is that the locomotives of this type bear his name. Several Mallet articulated compounds are now in use on European railroads and the B. & O. four cylinder articulated compound locomotive, which was exhibited at the St. Louis Exposition, is the heaviest and most powerful locomotive ever built. In the latter each pair of cylinders is connected with three pair of driving wheels, the rear, or high pressure, group being rigidly attached to the boiler, while the forward, or low pressure, group are fastened to a swiveling frame. Springs are used to restrain the motion of the frame and bring it into proper alignment. The wheel base of each group, of three pairs of driving wheels, is 10 feet, the total wheel base of the engine being 30 feet 8 inches. This allows of operation on curves of 20 degrees and upwards with less friction resistance than an ordinary consolidation engine of half its capacity.

The high-pressure engine has piston valves, the low-pressure engine has slide valves, and each engine is operated independently by the Walschaert outside valve gear.

The steam passes, from the dome, down the outside of the boiler to the high pressure steam chests. The exhaust from the high-pressure cylinders is connected to a receiver located between the high pressure cylinders. A pipe fitted with swivel and expansion joints leads from the receiver to the cylinder saddle of the low pressure cylinders. The exhaust from the low-pressure cylinder leads, as usual, to the smoke box but a swivel pipe is necessary. The high-pressure cylinders are provided with intercepting, reducing and low pressure exhaust valves, permitting the use of live steam, at a reduced pressure, in the low-pressure cylinders when an increased tractive power is required. The normal tractive power of 70,000 pounds may be increased to 85,000 pounds, the total weight being 334,500 pounds.

The following article on the "Electric and Steam Locomotives" is taken from the Railway and Locomotive Engineer of March, 1906, and deals, to quite an extent, with the performance of the above locomotive.

"One of the most important papers read before the members of the New York Railroad Club for some time was presented by Mr. J. E. Muhlfeld, general superintendent of motive power of the Baltimore & Ohio Railroad, on the subject of Large Electric and Steam Locomotives. The comparisons were drawn from records carefully compiled under Mr. Muhlfeld's supervision and the tests of efficiency, and the items of expenditure were recorded under conditions that preclude the possibility of any other motive than that of securing a just estimate of the advantages or disadvantages of the motive power used.

"Six electric locomotives are in use at Baltimore on the B. & O. System, four of them having been in use for a period of ten years, and the total cost of operating and maintenance, including the generation of electric current, besides general miscellaneous expenses, has been approximately $34.50 per hundred miles run per locomotive. Of this amount the running and shop repairs averaged $6.10 per hundred miles. In the case of the steam locomotive the expenses of maintenance averages $24.50 per hundred miles run or 30 per cent less than that of the electric engines under fairly similar conditions. Of this expense the shop repairs for labor and material of all kinds amounted to $3.16 per hundred miles, or nearly 50 per cent less than that of the electrically driven locomotive.

"It also must be borne in mind that these figures are not all. The fact was brought out that electric locomotives, where the source of power is separate from the machine which develops the hauling capacity, the first cost of the locomotive alone is, at the present time, about 50 per cent greater per pound of tractive power than for steam locomotives. To this must be added the greater cost of maintenance and operation of a current producing and distributing system, which is not required by an internal combustion locomotive. In electric locomotives also, the excessive weight concentrated on a short rigid wheel base results in extraordinary rail pressure which would be difficult to estimate in actual cost in the wear of rails. In the steam locomotives, especially in the articulated type, the highest degree of tractive power has been obtained, as can be readily imagined that when one engine begins to slip, the other engine meantime is gaining power, thereby preventing the stalling of a train at a critical moment. The conclusions carry out the generally growing impression that electric locomotives are better suited for the handling of suburban passenger traffic, and it does not seem to

be within the range of possibility that electricity will supersede steam as a motive power for the handling of heavy tonnage for any considerable distance. Indeed, it may, as Mr. Muhlfeld pointedly stated, make the use of heavy electric locomotives as compared with steam locomotives prohibitive, except in cases of absolute necessity.

"In the interesting discussion which followed, some of the leading electric experts claimed that the limit of the capacity of steam locomotives had been reached on the New York Elevated Railroad, and that the change to electrically driven motors had been a necessity. They seemed to have overlooked the fact that the passenger traffic on the elevated roads is about 20 per cent less at the present time than it was when the steam locomotives were in operation, owing to the relief obtained by the opening of the Subway and other improved avenues of transit. The advantages of the electric motor in city or suburban traffic is not based on any marked increase of speed or decrease of cost, but from the fact that there is here less dust and noise and no ashes, and in running short distances there is an undoubted advantage in the more rapid acceleration of speed.

"The absolute fairness which characterized Mr. Muhlfield's carefully prepared paper, and the able comments which it drew forth, are of such importance that in a published form it merits a wide circulation. The superiority of the heaviest kind of a locomotive was very clearly demonstrated in all kinds of traffic involving distances of over a few miles. The Mallet articulated (four-cylinder compound, built for the B. & O. by the American Locomotive Company, was claimed by Mr. Muhlfeld as being in every essential eminently superior to any combination of electric motors of equal tractive power, and while the electric experts persisted in claiming that the electric locomotive was still largely in the experimental stage, Mr. Muhlfeld cleverly maintained that the Mallet articulated compound was also an experiment and a very successful one, whereas, the electric motors recently put in operation by the B. & O. Company were not as satisfactory as those that were put in service ten years ago. The fact came out clearly that the electric locomotive reaches its most advantageous capacity in a single car of 10 or 15 tons, and beyond that limit the expenses of operation are largely in excess of that for similar service for steam locomotives."

Mr W. J. Wilgus, vice-president, N. Y. C. & H. R. R. R., sums up in a very few words the reasons for the adoption of electricity as a motive power. Especially in the vicinity of New York City, has this taken place. The following is taken from his discussion of a paper presented before the New York Rail-

road Club, March 16, 1906, by Mr. B. G. Lamme on "Alternating Current Electric Systems for Heavy Railroad Service":

"The motives in the minds of steam railroad men when considering a change of motive power from steam to electricity, in the majority of instances, are based upon one or both of the following conditions:

"(a) The desire or necessity to abate smoke nuisances in tunnels or terminals in large cities; or

"(b) The improvement of passenger service to attract an increased patronage by the public.

"In other words, steam railroads at the present stage of development of electricity as a motive power, do not consider its use from motives of economy but from those of necessity or from the broader policy of improving public service. To accomplish these objects, safety, reliability and earning capacity should be borne in mind."

BALANCED COMPOUNDS.

The balanced compound has forged ahead rapidly in the estimation of motive power men. Two valuable advantages are combined in the balanced compound. First, by using two high and two low pressure cylinders we obtain the economical double expansion of steam. Excessive cylinder condensation is eliminated, by the double expansion, and higher pressures and longer expansions are allowable. Second, the self balancing of reciprocating parts is obtained. The latter is obtained by arranging the cylinders so that each high pressure piston is moving in the opposite direction of its corresponding low pressure piston. When the reciprocating parts of the high pressure engine have the same weight as the corresponding parts of the low pressure engine, and each wheel is balanced for its revolving parts, the engine as a whole will be balanced, both horizontally and vertically, practically perfect as far as the action upon the track is concerned.

HAGAN BALANCED COMPOUND.

The Hagan Locomotive Works of Erfurt, Germany, build a balanced compound in which straight axles are used but a return crank is required for the coupling rod of one axle. The main rod of the forward cylinder moves between the rear cylinder and frame, and both cross-heads are carried back of the rear axle.

BALANCED COMPOUND.

coupled and three coupled axles) of and a low pressure cylinder are used on

types of balanced compounds were exhibited Exposition and included the De Glehn engine vania Railroad by the Alsacian Society of tion of Belfort, Germany; the Von Borries State Railways by the Hanover Locomo- Hanover, Germany; the Vauclain built for the & Santa Fe by the Baldwin Locomotive Works for the New York Central and Hudson River Works of the American Locomotive Co. of construction were taken from the Eng. Re- ually by the Eng. Societies of Purdue Univ.

Hanover or Von Borries engine has two high-pressure between the frames and two low-pressure outside the four of the cylinders are set in line across the en- center line of the leading truck and are coupled to driving axle.

weight of the reciprocating parts including the piston, cross head and main rod, for a high pressure cylinder pounds and for a low pressure cylinder is 598 pounds. Up osing of the Exposition, the Prussian State Railways had his type of engine in service with a lot of 19 additional construction."

The Cole engine includes two low-pressure cylinders out- the frames, connected to the rear drivers and two high-pres- cylinders inside the frame forward out of line with the low- and connected to a cranked driving axle. The steam tribution is controlled by four piston valves, the two on each being arranged tandem and operated on the same valve by the ordinary Stephenson link motion."

The record of this engine, while under test, showed that it maintained a speed of 75 miles per hour, 320 revolutions, for hour without any evidence of heating.

the first locomotive to be successfully tested above 200 without heating any of the parts." Ry. and Eng.

balanced compounds of two different have been built by the Baldwin Loco. of which a number are in use on the all four cylinders connected to the front driving arrangement of which a number are in use Burlington & Quincy, has the high pressure cy-

linders connected to the front axle and the low pressure to the rear axle.

"The weight of the reciprocating parts of the Santa Fe engine, as exhibited at St. Louis, for a high pressure cylinder is 964 pounds including cross head 307 pounds, piston 341 pounds and one-half of the main rod, 316 pounds. The Baldwin Company has been the pioneer in introducing the balanced compound into American service and has built the majority of engines of this type now in the United States."

"The De Glehn engine was built for the Pennsylvania Railroad for the purpose of making an experimental study of this type of engine which has proven so successful in France and other European countries. We refer to this as a French engine as Belfort is in Alsace, that part of Germany which was acquired from France after the Franco-Prussian war.

"The reciprocating parts are very light. The crossheads weigh 238 pounds each; the high pressure piston, 100 pounds; the low pressure piston, 242 pounds; the high pressure main rod 278 pounds; low pressure main rod, 425 pounds. While the engine may impress American designers as complicated, there can be no doubt but that it has been well designed, and the short time it has been in service it is said to have given very satisfactory results." Eng. Review, 1905, (Purdue Univ.).

The following remarks on the locomotive last mentioned are abstracted from the Editorial Correspondence of the February 22d, 1906, American Machinist.

"The engine has now done about 40,000 miles of service in the regular work of the road, and some very interesting facts have developed. After this amount of service the engine met with an accident which sent it to the shop, and advantage has been taken of the circumstances to completely dismantle it in order to examine the wear of the parts.

"The most striking thing about it is the superior workmanship of many of the parts, and of these the most note-worthy are the driving wheels. These wheels are forged, but in their painted condition no one would suspect it. Few cast wheels are so perfect in outline; in fact, were the wheels of brass castings they could not be more true to pattern than they now are. Of course it is easy to hint that they are an exhibition job with extra care devoted to them, but this does not alter one's admiration for them. The wonder is how they were made at all and I hazard nothing in saying that such wheels simply could not be produced in this country.

"The iron casting are also superior but uot to the same extent that the steel are but he speaks of a frame casting which is of

complex form, with many ribs and gussets, and of a degree of perfection not produced in American foundries.

"Another feature is the smallness of the bearing surfaces and their surprisingly small amount of wear. The rear or bearing faces of the driving-wheel hubs are deliberately turned away until the bearing surface left is but about 1½ inches wide, against about 3½ inches in Pennsylvania practice. After 40,000 miles of service, the tool marks are scarcely effaced, although experience would lead one to expect decided wear even with the much larger surface of Pennsylvania engines. The driving-box wedges again show no measurable wear. As regards the driving-wheel hub faces there is no apparent explanation of the results, but in the case of the wedges and some other parts it is apparently due to the remarkable hardness of the case-hardened surfaces. Other small surfaces are the driving box journals which measure 8x9½ against 9¼x12½ inches of the Pennsylvania engines, the low pressure eccentrics which are of 1½ inches face against 3, and the crank-pins which, are 3 15-16x3½ against 5⅜x4½ inches.

"No doubt the favorable results with these bearings are largely due to the divided stresses resulting from the compound cylinders but, nevertheless, no American designer would be bold enough to use them.

"Another marked difference from American practice lies in the diameter of the boiler tubes which are 2 25-32 against 1⅞ inches, outside diameter as usual on Pennsylvania engines of similar service. The flues, too, have eight internal or Serve ribs ¼ inch high to assist in absorbing the heat from the gases and in transmitting it to the water.

"Unfavorable as well as favorable experiences have resulted from the service use of the engine, the most notable being with the fire-box stay bolts. After only a thousand miles of service these began to break in an alarming manner and eventually nearly one-half of them had to be renewed. These bolts are of copper, as are the internal fire-box sheets, and were replaced with bolts of phosphor bronze. A possible explanation of their failure lies in the narrow water legs, which are but 3¼ inches wide against 4½ of Pennsylvania practice, but this explanation is not satisfactory. Presumably these spaces represent ordinary French practice and the question, why do these bolts give satisfactory service in France and promptly fail here? seems to be unanswerable.

"A remarkable example of what would be looked upon as bad designing lies in the oil cellars of the driving boxes, which, in addition to being very small, are so arranged that in order to renew their supply of waste it is actually necessary to remove

the wheels from the engine. On American engines this can be done without dismantling anything and in a very few minutes time.

"Another feature of this kind is the attachment of the various steam fittings of the cab to the boiler by gasket packing, where here metallic joints would be used as a matter of course.

"A lot of ten new enginesis nearing completion at Juniata in which some of the features of the De Glehn engines have been incorporated."

The three De Glehn compounds on the Great Western Railway of England have not produced the economy that they should have and up to a few months after being in operation a single engine with an equal load did a better performance than any of the compounds.

SUPERHEATED STEAM.

"Superheated steam is steam whose temperature is higher than that corresponding to its pressure as given in steam tables.

"Saturated steam is superheated in two ways; (1) by separating it from water and imparting additional heat to it; or (2) by allowing it to expand without doing work; in which case superheated steam of a lower pressure will be formed."

The latter method is not employed in locomotive service. Saturated steam is not a true gas although experiments have shown, when superheated about 20° F, it behaves very nearly like a true gas.

"Steam cannot be superheated while in contact with water, owing to the fact that any heat added would go to form more saturated steam, without effecting the temperature of that already formed. Neither can superheated steam exist in the presence of water. If too much water is present, a sufficient part of the excess heat of the steam will be used to evaporate and superheat it, thereby reducing the excess of heat. If there is too much water for the excess heat to evaporate, steam will be reduced to the point of saturation, the superheating being entirely used up in converting the water into saturated steam. If saturated steam suffers any loss of heat, some of it will condense. Superheated steam, on the other hand, must lose all its excess heat before condensation commences."

"Jacketing and superheating both reduce interior wastes in the steam engine cylinder, but the former is not applicable to locomotives for various reasons, and the latter may entirely suppress initial condensation, reduce other losses, and approach more nearly the ideal condition."

International Library of Technology, Pub. by the correspondence Schools, Scranton, Pa.

[illegible]

[illegible] superheat of steam [illegible]

[illegible] per cent. [illegible] superheated super- [illegible] the same saving.

[illegible] subject revived con- [illegible] superheat was quite exten- [illegible] latter part of this period. Hirn, in [illegible] experiments made by him at Colmar, which were the most carefully conducted tests that had up to that time been carried out, and showed that, on a simple engine working with a boiler pressure of 55 lbs. economies of [illegible] per cent could be obtained with superheat of 100 to 190 deg. F. In 1859 John Penn read a paper before the Institution of Mechanical Engineers describing several applications to steamships, the superheating consisting of a number of tubes about 2 inches diameter placed in the uptake just as it left the boiler, through which the steam passed on its way to the engine. The superheating surface was about 15 per cent of the boiler heating surface, and with a boiler pressure of 20 lbs. on a condensing

engine, about 20 per cent saving of fuel was obtained with a superheat of 100 degs. F. John Ryder, in 1860, in a paper before the same society described the Parson and Pilgrim superheater, which consisted of two horseshoe-shaped pipes placed in the internal flue of the boiler over the fire grate, and the Partridge, which was a cylinder filled with tubes through which the gases passed, the steam being around them. Both of these systems were stated to have given good results, which may appear rather questionable in the case of the former, but a total of 5,000 h. p. had then been equipped. The superheating surface employed was $2\frac{1}{2}$ to $2\frac{3}{4}$ sq. ft. per nominal horse power, or about the same as that described by Penn, and the economics obtained were practically equal.

"Several other systems were in more or less extensive use about this time, such as the Crossland, Wethered, etc., and extensive experiments were carried out by Isherwood, in the American Navy, which confirmed the good results obtained abroad. While a large amount of evidence was thus created in favor of superheating, and it was then employed to a considerable extent, placing it beyond the experimental stage, it gradually gave way before the development of increased boiler pressure and compounding, which commenced about 1865. When boiler pressures were from 20 to 40 lbs., superheaters in the uptakes, which gave 100 to 125 degs. of superheats, could be employed without exceeding a temperature in the cylinder at which the animal lubricants used in those days would decompose and attack the valve faces and cylinder bores, but as the pressure was increased, the same amount of superheat could not be used. The absence of moisture in the superheated steam made lubrication necessary, and the packings used on valve stems and piston rods were also badly adapted for steam at high temperatures and gave considerable trouble when 350 degs. was exceeded. Trouble was also experienced in the superheater tubes, caused by deposits of salt on account of the use of the jet condenser, which was then universal. By employing a high boiler pressure and avoiding cylinder loss by compounding, the same economy could be obtained as by superheating with a decrease in trouble, and its use gradually declined until about 1870 it was rarely employed on new work, excepting by the Alsatian group of engineers, by whom it was never abandoned. With the introduction of hydrocarbon lubricating oils, balanced valves and improved packing, the use of considerably higher temperatures became possible, and in 1890, interest in this subject was renewed by the attention drawn to the results being accomplished in Germany by such engineers as Gehre, Schwoerrer, Uhler and others. Many results were published, all of which showed a gain from the prac-

[illegible] their ap- [illegible] similar lines [illegible] progress [illegible] stationary prac- [illegible] and it has [illegible] superheat, say [illegible] boiler being [illegible] rather than [illegible] superheated [illegible] experimenting by Mr. [illegible] 1894 in pro- [illegible] superheated to 700 [illegible] pressures. The results ob- [illegible] and De Grahl in 1894 [illegible] small engines. [illegible] 500 plants [illegible] working on the [illegible] apart from these, highly superheated steam [illegible] said to have come into general use. In view of [illegible] applications of superheated steam to locomotives, the [illegible] of its introduction into stationary and marine prac- [illegible] Moderate superheating, employing temper- [illegible] to 100 deg. above that of evaporation, first scientifical- [illegible] by Hirn, introduced extensively into early Eng- [illegible] practice by Penn and others and then abandoned; [illegible] in stationary practice in Alsace by Hirn's pupils and [illegible] has in the last ten or fifteen years, become extensively [illegible] stationary practice with increasing steam pressures. High [illegible] superheating, developed by Schmidt, has been economical and [illegible] where employed, but so far, is not in general use.

[illegible] superheated steam is supposed to have been first applied to locomotives on the Chicago, Burlington & Quincy Railway in [illegible] the front tube sheet being set back some distance into the boiler and the superheater, consisting of a separate cylinder in which the tubes formed practically a continuation of the boiler tubes and to which the steam entered by the dry pipe, and [illegible] by pipes connected to the bottom [illegible] have actually superheated the steam [illegible] showed some economy which was [illegible] pay for its increase in cost [illegible] it was subsequently [illegible]

[illegible] Prussian State R[illegible]

coupled express locomotive built at the Vulcan Works in Stettin, and to another of the same type built by Henschel & Son at Cassel. The first of these, No. 74, of the Hanover Lines, was used in heavy passenger service on the State Railroads of Hanover. The second, No. 131, of the Cassel Lines, was used in passenger service on the State Railroads of Cassel.

Mr. Schmidt then designed what is now known as his smoke-box type of superheater, and in 1899 one engine was put in service with this device. This engine, No. 36, for the Hanover Lines, was built at the Vulcan Works. The next engine, No. 74, for the Berlin lines of the Prussian State Railroads, was built by the Borsig Works of Berlin. This locomotive was placed on exhibition at the Paris Exposition.

Mr. Storm Bull in a paper, on the Locomotive Exhibits at the Paris Exhibition in 1900, before the A. S. M. E. described the superheater as follows:

"The superheater is built according to the Schmidt patent, and consists of a nest of 60 tubes of 1½ inches outside diameter. These are arranged in a cylindrical shaped chamber surrounding the smoke-box proper. The flue gases used for superheating the steam come through a tube 10 inches in diameter, installed in place of a sufficient number of small tubes at the bottom of the cylindrical boiler. The gases from this tube pass up and around these tubes and from them into the stack. The 10-inch tube serves, of course, to heat the water in the boiler, but the diameter being so large the gases arrive at the superheater without having lost very much of the heat. By means of dampers more or less of these gases may be made to pass through the superheater, and besides this regulation by hand, the amount of vacum due to the blast will also influence this flow. The greater the power developed by the locomotive the greater the vacuum, and, necessarily, also the greater the amount of gases that will come to the superheater. It is stated that this superheater is capable of raising the temperature of steam of 176 lbs. pressure to 626 degrees Fahr., which is superheat of nearly 250 degrees Fahr."

In 1902, Mr. Garbe read a paper, before the Berlin branch of the Institution of German Engineers, in which, he gave the reasons that led him to a consideration of the advantages of superheated steam, and discussed the benefits and results obtained.

By the end of 1904 the Prussian State Railways had put into service 127 engines using superheated steam, all except the first two and the last one having the smoke-box type of superheater.

Mr. Schmidt also designed the smoke-tube superheater. In the modification of this design several of the ordinary tubes, in the upper portion of the tube sheet, are replaced by a number

of 5 inch tubes, reduced to 4 inches at the back tube sheet, and each large tube contains two loops of $1\frac{1}{4}$ inch superheater pipes connected at the back end by steel return bends. The steam passes from the dry pipe to a transverse header in the smoke-box, which is separated into two portions, one for saturated and the other for the superheated steam. The loops of superheated tubes are expanded into flanges and these are secured to a face on the lower side of transverse header. By this arrangement the steam passes from the saturated steam compartment through the superheater pipes to the superheater steam compartment and thence to the steam chests. In another form the face on the header is in the front, instead of underneath as in the previous case, and instead of the superheater pipes being formed in single loops, they are in double loops. In the latter method the rate of flow is doubled and also the heating surface per loop. Mr. Schmidt advises that the double loop arrangement is not only superior in construction but that it gives a higher degree of superheat.

The Schenectady, or Cole, superheater, built by the American Locomotive Company, differs from the Schmidt smoke-tube type chiefly in the arrangement of the headers. Usually an inner and an outer pipe are used to lead the steam to the rear end of the superheater tubes in place of looped pipes. In this design the superheater tubes are expanded into a sectional header, which is itself divided into two departments for the saturated and superheated steam. These sectional headers are then bolted to the main header in place of each pipe being bolted as in the previous arrangement. Each sectional header can be removed without disturbing the others and is simple and convenient for repairs. The inner and outer pipe arrangement reduces the number of joints. While there are many modifications worthy of note, time does not admit of taking them up in detail, but the general characteristics of each type are given.

PIELOCK SYSTEM.

In the Pielock type of superheater a box like arrangement is built within the barrel of the boiler. The box is divided by vertical plates parallel to the tubes into several compartments. These compartments are joined alternately at the top and bottom of the plates and thus the steam is brought into contact with all the tubes and becomes superheated. As there are a large number of tubes fastened to the box it has not been found necessary to have any special fastening. To exclude the water, the tubes passing into the superheater box are light rolled into the end plates of the latter by means of a mandrel, but as the pressure within the box and in the boiler is essentially the same little

troubled is experienced. The steam passes from the dome through the passages of the superheater box and then by a separate pipe to an enclosed chamber in the dome from which it passes to the steam chests. The steam becomes superheated in circulating among the tubes but practice has proven that the circulation of steam acts as effectively in keeping the tubes cool as does water. Excessive heat in the superheater tubes is overcome by not placing the box too near the fire-box and aided to a great extent by the reduced draft, due to a shutting off of the steam.

The Vaughan-Horsey superheater is a development introduced by Mr. H. H. Vaughan, assistant to the vice-president, and Mr. A. W. Horsey, mechanical engineer. Both of these men, have had much experience with the superheater, as used on the Canadian Pacific, and it has been their aim to simplify the construction, and at the same time reduce all possible mechanical difficulties to a minimum.

The superheater fire tubes are 5 inches outside diameter, 4⅜ inside diameter and are swagged down to 3½ inches inside diameter for a distance of about 5 inches at the back end. They are then threaded and screwed through the back tube sheet and beaded over. At the front tube sheet they are expanded to 5¼ inches outside diameter and are beaded over. Each large fire tube contains two of the small tubes from the top header and the corresponding return tubes to the lower header. The circulation space about the small tubes is kept uniform by casting lugs on the return bend. The small tubes are 1¼ inches, solid drawn weldless steel tubes, the inside diameter being 15-16 inches, and are upset at one end and forged into the desired shape. They extend to within about 30 inches of the back tube sheet and are there fitted into heavy cast steel return bands. Special cast steel fittings screw into the header and these are connected to the tubes by mild steel union nuts. A 1 1-16 inch copper wire gasket is used in the union nuts. The headers are entirely independent and any pair of smaller tubes may be taken out or replaced at will. As the headers are separate the danger of the superheated steam becoming cooled off by means of the saturated steam is eliminated. A small steam cylinder regulates a damper which controls the flow of gases through the superheater tubes. This arrangement prevents the hot gases from injuring the superheater tubes when the engine is not taking steam. No difficulty has been experienced in keeping the joints tight.

Results have been received from the important railways of Europe having engines equipped with superheaters. Mr. H. H. Vaughan, in his paper as previously mentioned, gives many re-

sults. Thus far that is about all the information available in this country. Several other American railroads have engines equipped with superheaters, and while they have all proven satisfactory, no exact information is obtainable. The general results show that it is practicable to operate with a temperature of 600 degs. F. without difficulty and that high temperatures produce much better results. In general the simple locomotive equipped with a superheater of sufficient heating surface to procure a fair degree of superheat gives as good, if not better, results than the compound. The cost of the superheater is about $1,000 per engine and experience has proven it not expensive to keep in operation or does it necessarily decrease the boiler efficiency.

To secure the required degree of superheat from one-third to one-fourth of the total heating surface should be used in the superheater tubes. In the small types this is very easily obtained but in the larger types it is liable to reduce the boiler power. The figures given of some of the recent locomotives put in service will show the above ratio to be from one-tenth to one-fourth.

Two new types of locomotives are now being experimented with on the Belgian State Railways. The two classes are similar in construction except in the 19 class all the main rods drive upon one pair of wheels, according to the central European practice, while in the 19 A class the four rods drive upon two pairs of wheels. This allows of comparison, between the two, as to the better method of coupling. The engines are of the four cylinder compound type having all the cylinders in one transverse line. Piston valves are used throughout, operated by Walschaert valve gear. One valve gear is used for each pair of cylinders and the transmission of movement is obtained through horizontal traversing rocker levers.

The locomotives were built by the Cockerill Works of Seraing, Belgium, and both are equipped with Cockerill superheaters, of similar design. The superheater pipes, there being three $1\frac{1}{4}$ inch pipes in each flue of 4.2 inches diameter and 13 feet $1\frac{1}{2}$ inches in length are placed in the upper rows of fire tubes. There are 30 large fire tubes, 15 on each side of the boiler, or 90 reheating pipes, having a reheating surface of 495 square feet in Class 19. The object of separating the reheating tubes into two groups will be taken up a little latter.

Superheating in Belgium, Austria and Saxony is now carried to a very high temperature, from 570 degrees to 660 degrees Fahrenheit. Iron pipe is necessary to resist the high temperatures but they have found that a moderate degree of superheat barely warrants the extra first cost and maintenance.

To superheat the steam before its entrance to both the high-pressure and low-pressure cylinders, or, on the other hand, to

reheat the steam after its exhaust from the high-pressure cylinders, is a question of much importance to motive power men. It is hoped that these two classes, 19 and 19A, will enable them to settle this question. No results have as yet been published by the Cockerill Works.

The steam, if it is to be superheated previous to its entrance in the high-pressure cylinders, passes by means of a pipe from the dome to the diaphragm chamber. From the diaphragm chamber it passes forward through the left hand group of pipes to the dry steam collector in the smoke-box and from here to the high-pressure cylinders. After exhaust from the high-pressure cylinders, the steam is passed back once more to the fire-box end and then through curved pipes it is taken to the reheating receiver on the right hand group of pipes to the collector, from which it is taken to the low-pressure valve chests. The direction to be taken by the steam is under control by a three-way throttle valve beneath the dome, or by corresponding valve beneath the smoke-box, both being connected together and operating in unison, so that all movements are effectively worked from the engineer's throttle handle or the foot plate. Thus it is possible to allow the steam to pass directly from the dome to the high-pressure cylinders, devoting all the apparatus to superheating the steam before it enters the low pressure cylinders. If the latter method is found the most advantageous it will be possible to dispense with certain parts of the superheater, and thus reduce the obstruction in the smoke-box.

In the record of recent construction the Belgian State Railways have three new types of locomotives. They are all six-connected; one, for heavy passenger service, with inside compound cylinders and piston valves; the other two are a four cylinder compound and a four cylinder single expansion. Superheaters have been applied to all and will no doubt elucidate other interesting questions.

Experiments are also being carried on with a two-cylinder compound consolidation freight locomotive fitted with a Cole superheater by the Minneapolis, St. Paul & Sault Ste. Marie Ry., and it is hoped some comparative results will be obtained later.

Compound locomotives equipped with superheaters are also in use on the Canadian Pacific Ry. and results will be given as compared with simple locomotives equipped with superheaters.

THE FUTURE

From the rapid growth of the locomotive during the past few years it is impossible to predict what will be the size and

[illegible] of the [illegible] of the future. The advantage from [illegible] is in favor of the heavier and more powerful locomotives. [illegible] difficult to compare the performance of the [illegible] locomotive with the lighter locomotive [illegible] years ago. A committee was appointed and in [illegible] presented a [illegible] prepared report before the Master Mechanics' [illegible] taken from a [illegible] road and compared [illegible] road. The report says in part:

[illegible] from the saving in train and engine crew [illegible] power. It seems [illegible] when the representative [illegible] showing an expenses to be [illegible] power, but that an actual saving [illegible] result when based on the [illegible]

[illegible] the advantage and [illegible] principle [illegible] and power. In [illegible] the [illegible] must be [illegible] the principles [illegible]. Such experiments [illegible] of such a com[illegible]

ENGINEERING BULLETINS

[illegible] OF BULLETINS ISSUED UP TO THE PRESENT BY THE ENGINEERING EXPERIMENT STATION OF THE IOWA STATE COLLEGE

Bulletin No. 1. The Iowa State College Sewage Disposal Plant and Investigations. (Now out of print.) This bulletin describes the college plant, the first in the state, and gives the results of the first year of operation, including bacterial and chemical analysis. [illegible] pgs., 6 cuts.

Bulletin No. 2. Bacteriological Investigations of the Iowa State College Sewage. Results from Sept. 1, 1899, to Sept. 1, 1900. 22 pgs.

Bulletin No. 3.—Data of Iowa Sewage and Sewage Disposal. This bulletin gives a number of gaugings and analyses of Iowa sewage from different towns, and of various kinds, together with the detailed result of the operation of the college sewage disposal plant from May, 1900, to May, 1901. 27 pgs., 5 cuts.

Bulletin No. 4.—Bacteriological Investigations of the Iowa State College Sewage Disposal Plant. Results from 1898 to 1902. 19 pgs., 3 plates.

Bulletin No. 5.—The Chemical Composition of the Sewage of the Iowa State College Sewage Disposal Plant. Results from 1898 to 1902. 11 pgs.

Bulletin No. 6.—Tests of Iowa Common Brick. This bulletin gives the results of several hundred tests of seven different varieties of common brick manufactured in Iowa. Crushing, transverse breaking, absorption and freezing and thawing tests are given in each case. 23 pgs., 28 cuts.

Bulletin No. 7.—Sewage Disposal in Iowa. This bulletin gives detailed descriptions, usually with plans, of all sewage disposal plants in Iowa up to December, 1903, with the history of sewage disposal in the state, and full details of the operation of the several plants, including chemical and bacterial tests of efficiency. This paper was awarded the Fuertes Medal by Cornell University June, 1904, and the Chanute Medal of the Western Society of Engineers for 1903.

Bulletin No. 8.—This bulletin gives the results of several hundred tests of seven varieties of dry press brick commonly used in Iowa. Crushing, transverse breaking, absorption and freezing and thawing tests are given in each case. 19 pgs., 8 cuts.

Bulletin No. 9.—Notes on Steam Generation with Iowa Coal. This bulletin gives a summary of a number of analyses of Iowa coal and tests of their heating power together with a discussion of the special difficulties encountered in burning Iowa coals and the best methods of overcoming these difficulties. 16 pgs., 3 cuts.

Bulletin No. 10.—Dredging by the Hydraulic Method, by George W. Catt, President of the Atlantic, Gulf and Pacific Dredging Co.

Bulletin No. 11.—An Investigation of Some Iowa Sewage Disposal Systems, by L. H. Pammel and J. B. Weems.

At this point the form of the bulletin was changed to a periodical published six times a year and the system of numbering the issues was changed accordingly.

Volume II, No. 6.—The Good Roads Problem in Iowa. This was the first bulletin published by the Iowa State Highway and it gives a general discussion of the good roads problem in Iowa with instructions for building concrete culverts and for making King road drags.

Volume III, No. 1.—Tests of Cement. This bulletin gives a general discussion of the properties of cement, together with the results of several hundred tests made in the laboratory of the Engineering Experiment Station. Standard specifications for cement are also given.

Volume III, No. 2.—State Railroad Taxation. This is a discussion by Professor F. C. French, Associate Professor of Railway Engineering at the Iowa State College, on the different methods which are employed in taxing railways.

Volume III, No. 3.—Steam Generation With Iowa Coals. This bulletin reports the results of a number of investigations on mechanical stokers with Iowa coals, together with a summary of the results of the government tests on Iowa coals, hand fired. By Professors G. W. Bissell and W. H. Meeker.

Volume III, No. 4.—Incandescent Lamp Testing. This bulletin gives a comparison of the various kinds of incandescent lamps which

are on the market, with respect to their initial candle powers and efficiencies and a determination of the ratio between the mean spherical and horizontal candle powers. Prof. L. B. Spinney.

Volume III, No. 5.—Steam Pipe Covering Tests, with a special object of determining the value of steam pipe coverings of varying thicknesses, based upon the results of tests and compiled by Prof. W. M. Wilson.

Volume III, No. 6.—Sewage Disposal in Iowa, 1904-05. This bulletin, which is now nearly ready for the press, will continue the subject of sewage disposal in Iowa where left off by Bulletin No 7, and will give a description of all plants constructed since 1903. It will also give the results of operation of every plant in the state during the years 1904 and 1905, including chemical and bacterial tests of the efficiency of each.

Any of the above bulletins can be obtained by writing A. Marston, Director, Ames, Iowa.

The Third Annual Meeting convened at Ames, January 23, 24 and 25, 1907. As in preceding years, the sessions were held in Engineering Hall, at the Iowa State College. The first session was called to order promptly at 8 P. M., Wednesday the 23rd. Meetings were held on Thursday forenoon, afternoon and evening, and Friday forenoon and afternoon.

FIRST SESSION

Wednesday evening, 8 o'clock. President L. L. Bingham, of Estherville, in the chair.

President Bingham: The convention will come to order. First always at a gathering of this kind are the addresses of welcome. The first as printed on the program will be from Mayor Sheldon, of Ames. Will ask whether he or some one representing him is present. If not, the address of welcome on behalf of the college will be given by Professor Bissell.

ADDRESS OF WELCOME

Professor G. W. Bissell, Iowa State College.

I remember reading, and have committed to memory some portions of a very beautiful piece of poetry called, I think, the "Yarn of the Nancy Bell." The refrain of that poem is to the effect that the writer is in his own person several other persons. I believe he is the

"Cook and the captain bold,
And the mate of the 'Nancy' brig,
And a bo'sun tight and a midshipmite,
And the crew o' the captain's gig."

That seems to be my situation tonight. I had expected to follow a worthy speaker, and I expected still further, to not be here at all. But as it is I am in danger of being tomorrow morning in the predicament of persons who are not able to put their hats on; not for the reason which seems sometimes to account for that condition, but because of the very great importance which attaches to the duty which I have to discharge this evening, namely, in representing President Storms, and in filling in the time which was assigned to him and to another.

I will not attempt to perform this duty as well or as gracefully as either one of them could, but I want to, in a few words, express to you, so you will be sure that I mean it, that you are heartily welcome to this college and to the city of Ames for your convention at this time. I have been very much surprised by the large numbers who gathered here so early in the day, really before the convention began. I think the committee on arrangements was also surprised, at the number of persons arriving so long before the opening session of the convention.

You are a body of men engaged in very important work. The industry of cement using, and that I suppose means mainly the manufacturing of cement into concrete and other forms for building and other structural purposes, is, it seems to me, one which is to assume more and more importance. It has been my privilege in the past few weeks to see some very notable examples of concrete construction. About two weeks ago, while at Sioux City, I visited the Cudahy Packing Company's new plant, which is a six, seven or eight story monolithic steel concrete institution. The forming of the building is much on the plan of the steel building with which we are familiar, namely columns and girders in between the outside and inside walls or partition walls, and I-beam stringers supporting reinforced concrete floors and ceilings. It was a very imposing piece of work, and was claimed by the owners to be very satisfactory indeed. It may be interesting to state that the cost was not excessive. I believe

about 12 per cent more than brick and wood construction would have cost.

I saw the other day a concrete steel chimney, self supporting. It was almost as slender as a steel chimney, so slender as to make its appearance rather unfavorable, because it looked as though it had no business to stand up at all. We are accustomed to see masonry chimneys so much larger in comparison with height, that when we see concrete, which has the appearance of masonry, in slender form, we are somewhat shocked at first. But we will become accustomed to it and I predict that the time will come when the concrete chimney will be the more common and will no longer appear unusual and out of place.

You have a good program before you, you have much to do this evening, and it behooves me to make my remarks brief. We are carrying on here an Engineering School of some magnitude. We are pleased to have you here, so that you may see what we do when we are at work, and that our students may have the opportunity of rubbing up against you and getting some practical ideas. I am sure the meeting between you and us cannot but be beneficial to us, and we hope that it will be beneficial to you.

As you circulate around through the college buildings, remember that everything is public. If you see a door closed, do not back away from it until you find out whether or not it is locked. And if it is locked, and you want to get in, ask somebody to let you in. You will most always find that you will be gladly admitted. This applies to all the buildings. We want you to make yourselves at home, to use our rooms and time to the fullest extent, and we are anxious to do everything we possibly can to make you feel that we welcome you here. On behalf of the college, its officers and students, I bid you a hearty welcome to Ames and to the college grounds, and trust that your convention will be in all respects a profitable one.

President Bingham: I will ask Vice-President Geo. H. Carlon, of Oskaloosa, to respond to Professor Bissell's welcome.

RESPONSE TO ADDRESS OF WELCOME

Vice-President G. H. Carlon.

Mr. President, Professor Bissell: When the executive committee met in Des Moines to decide on the place for holding the convention, there seemed to be but one place where we should come. That was Ames. There was a reason for this. We had our first meeting here, and the last meeting, and we have never forgotten the kind treatment we have received at Ames. You have before you a body of representative business men, you

might say, of the state of Iowa, and I am sure there is a warm spot in the heart of every one of us for this city. We are glad to be with you; we hope to be a benefit to you, and we trust it will be a benefit to us. I can voice the sentiment of every cement user in this room, I am satisfied, when I say that we thank you from the bottom of our hearts for your kindness, good will, and good feeling. I trust this may be the best meeting we have ever had. Thank you.

PRESIDENT'S ADDRESS

L. L. Bingham, Estherville, Iowa.

Five years ago practically all the cement being used was by contractors. Today nearly every village in the state has its factory or factories for the manufacture of some one or more of the various products now so common as to be no longer considered novelties. Of these, building blocks rank first, but sidewalk squares, brick, posts, sewer pipe and drain tile are also important and other lines are attracting increasing attention.

No business could expand so rapidly without drawing into its ranks a large proportion of raw recruits who, however bright and eager and earnest and enterprising they might be, could not expect, without training and discipline, to become regulars, to say nothing of captains, in the industry of their perhaps too precipitate choosing.

Disappointment and loss were inevitable and wide-spread, more especially among makers of cement blocks. Ready sale value of their plant and equipment considered, probably not over 20 per cent of the factory cement users of the state have made interest on the money invested and even a grocery clerk's salary for themselves. The bank accounts of the large majority would have been in much better shape had they continued in their former callings.

The practical question is, however, seldom toward the past. By what means present conditions were brought about is of little moment compared with the importance of a sane judgment of the situation as we find it today, and a study of ways and means to haply compel it to yield the family bread and butter.

Unquestionably some now in the block making branch of the industry would better stop short, realize what little they can on their investment, pocket the loss as cheerfully as their innate strength of soul will permit, and re-engage in their former line of work. Mere hope for a better turn of affairs without something a deal more substantial in the way of common sense sizing up of reasonably sure more favorable conditions, is a sandy foundation unable long to withstand the constant wash of current expenses.

There is, however, a basic strength to the cement users' business which fully warrants most block makers in staying in it, especially if they are also working along other cement lines. Comparatively few enterprises are successful from the start. Most have a year or two or more of hard sledding before the income exceeds the outgo. Cement is a factor of so far-reaching and constantly increasing importance in the industrial life of today, that we who receive it from the makers, compound the concrete, and mold it into the varied forms demanded by the bill paying public, are going to profit in the long run just in proportion to the satisfaction we give that public, and the wisdom and economy with which we conduct our business.

Again the fact that ours is essentially a local industry is in our favor. With three-fourths of our raw material readily available in any quantity in most sections of the state, the serious competition of large manufacturing centers is not likely.

Further, the work being done at the United States Testing Laboratories at St. Louis, and in state institutions like this at Ames is doubtless to be of material assistance in giving us needed information as to how to handle and what to expect from cement. Till now even the most experienced have in a measure been working in the dark. What temperature and what humidity are necessary for best results in curing? For how long should this temperature and air moisture be maintained? Do the crystals formed in setting attain their full strength as they form, or do they become stronger in curing, like steel in tempering? If the latter, to what extent is moisture essential to this hardening, or is its work confined chiefly to the period of crystal formation? What agencies other than heat and moisture are advantageous in effecting more perfect crystallization and hardening, and how are they to be used? Such questions as these are continually coming up, and their authoritative answers will mean progress for the industry, and dollars in the tills of the informed cement user.

We have as other allies our exceptionally good trade journals, the makers of reinforcing materials, and such of the machinery men, and makers of molds and forms and tools, as are honorable and well informed, and reasonable in their charges. With all these men now loyally lining up to further our mutual interests, with nature and the cement mills furnishing the materials, and the public increasingly anxious to buy when shown we have the goods to deliver, at prices comparing favorably with those of other and oftimes inferior materials, the problem is pretty well simmered down to the personal equation—the cement user and his qualifications for an ordinary business career. This means, was he born for battle; do all his faculties joyously answer the summons to the struggle and carnage and

devastation of active campaigning?—for competitive business is war just as truly as that of the tented field. There are exceptions, but one man's success usually means that other men's families shall have less. Some are such natural warriors as to minimize the necessity for other qualifications much more important to the man constituted with an ofttimes distressingly persistent consideration of the other fellow's welfare. Such a man most certainly cannot divide his energy and brains with the saloon and poker, and expect to succeed at cement work. He must know concrete *thoroly*, and be constantly searching for ways of producing more satisfactory results—more waterproof, more sightly and more adaptable blocks, stronger posts, more accurate alignment of forms and neater finish; and adequate strength and permanency for all his work. He must so plan and arrange his work, so select and combine his cement and sand and gravel, or crushed stone, and so organize well paid and efficient workmen as to get maximum production for minimum cost. He must be alert to discover possibilities for new business, a student of salesmanship, and withal a tireless, persistent pusher. To such cement users success is certain. It is no royal road of ease and self gratification, but it is a promising way of making a living; and a little extra for easing the burden and brightening the pathway of our less fortunate fellow travelers.

On the whole, the cement users of Iowa are to be congratulated on the decidedly favorable outlook for their business. The general prosperity of the state is phenomenal, and greatly increased work in our various lines is being projected. Expansion is especially noticeable in road work, drainage, and reinforced concrete, and the building block branch evinces signs of recovery from its temporary stagnation. Properly proportioned, mixed and thoroly compacted material, water-proofed exterior, including mortar joints, and a greater variation in shapes and sizes and attractive finish will cause the public to look with increasing favor on this material for building purposes. Satisfactory results *can* be attained, and manufacturers who demonstrate their ability in this direction will command a growing patronage.

A few words relative to these annual conventions. Their purpose is educational. The public is finding concrete so well adapted to a constantly increasing number of practical purposes, that every cement user is again and again called upon to do work until then unattempted in his particular locality. It is essential that he know how. No short course has as yet been established. Aside from our trade literature, these conventions are practically our only means for becoming properly informed and keeping up to date in what may be done, and ways of doing

it. Otherwise, each cement user and his patrons must pay the price of individual experiment. Ordinarily that is decidedly poor economy as compared with attendance on conventions. The fact that you are here is evidence of your *thrift*, as well as your purpose to be at the front in all matters pertaining to concrete.

I wish to suggest, especially to those who have not heretofore met with us,

1st. That while we would not refuse the privilege of this convention hall to any conscientious worker in cement, we certainly feel that each and every one who attends should pay his dollar and become a member of the Association. The information you receive is worth many times that modest sum, and I am sure no manly man cares to be a convention pauper—appropriating the benefits without sharing in the attendant expense to the Association. If you have not already done so, by all means see the secretary and get your badge—evidence of having done the square thing by the rest.

2nd. Be present punctually at every session, and listen attentively to the presentation of *every paper*. The subject may not be one in which you have yet become interested, but since you are a cement user you doubtless *will* some day soon, and it pays to be informed when the chance for the contract comes.

3rd. Don't be backward about asking questions. State your difficulties. Some of us may have been stuck at the same place, and know the way out.

4th. Be ready to answer these questions and to discuss the various papers. If you know where the difficulty lies and have found the remedy, pass the information on. Any man who will come here and take, take, take—without returning the compliment when able to do so, fails to measure up to the standard of the ideal cement user. We are here to impart, as well as receive.

5th. Remember that you will fail to get a large part of the possible benefit from this gathering unless you are sociable. Rub up against each other before and after sessions, and *talk concrete*. You will be surprised how many points will be brought out that fit your case exactly, and how many nuggets of cement wisdom you will gather where least expected.

We are here for only a few hours, and if wise will make the most of them in ways that will mean dollars next summer.

President Bingham: The next number on the program as arranged for this evening is by Mr. R. G. Coutts, of Grinnell, on

THE DEVELOPMENT OF THE PORTLAND CEMENT INDUSTRY

Mr. Coutts: Mr. Chairman, Gentlemen of the Convention: I have heard it said of a certain congressman that when he got

real excited in a session in congress, he had a habit of saying, "Mr. Speaker, I don't want to make a speech; I have something to say." I have something to say to you before I make any speech. Your president, Mr. Bingham, wrote me some weeks ago and asked me to suggest two or three subjects for this convention. I thought I could read between the lines of his letter. I thought perhaps Mr. Bingham is setting a trap, and if I suggest something that he thinks I think is all right, he will ask me to take that discussion. So I mentioned a subject that he knew I covered pretty thoroly last year in my annual address, and felt certain that he would ask someone else to take it. I thought he wouldn't want me to hash it over again, but I was mistaken. He came right back at me with the request that I take up the subject and discuss it.

But I was very much mistaken when I thought I had covered the subject of the development of the Portland cement industry. I found out that Gideon's army wasn't anywhere in comparison. So I have undertaken to make a few remarks or suggestions in regard to this industry that may be new to some of you, for they certainly were new to me when I started to investigate the subject.

The title of this paper sounds a good deal like a "chestnut," but be that as it may it represents a condition that surely exists. Personally I know of no industry that has shown such a remarkable development as has the one under discussion. It is intensely American, and reflects the American spirit. And when I say the American spirit I speak of that in contrast with the European. The European is noted for his stable habits; he seems to enjoy treading in the beaten track; he is satisfied to let well enough alone. Not so with the American. He is continually looking and planning for something new. His restless spirit pushes him out of the old ruts, and no matter what comes up, if it has any merit, he is ready to take hold of it with all the force of his indomitable will and refuse to give up until his efforts are crowned with success.

I think that the last quarter of the 19th century and the opening years of the 20th have been marked or noted for 'fads' so called. About 1880 it looked as if the roller skate was going to take this country. Then appeared the bicycle which became so common that our city councils had to enact ordinances to protect pedestrians on the sidewalks of our cities. Now we have the automobile and it is still with us and perhaps has come to stay. Then we have the foot ball 'craze.' The postal card 'craze' (which has now run to an estimated extent of one hundred and fifty thousand different varieties), and many others.

And now we've got the cement 'craze,' or rather it has gotten us, and it differs very materially from any which I have

mentioned in that it has certainly come to stay. Having a very humble origin, it immediately demonstrated that it was no delicate child, and although it has already attained gigantic proportions, it today shows evidence of still greater growth than its most ardent devotees ever dreamed of. Its development has been simply phenomenal, and the most remarkable feature of this growth is that it has been gradual and steady. It has taken no steps backward in the past twenty years. Every year has shown an advance over the previous year, and that advance increases greatly as the years go by.

I have no desire to weary you with statistics, but some of these are so striking in comparison that I can not resist the temptation of calling your attention to just a few. The Manufacturer's Record for July 5th, 1906, makes this remarkable statement: "In 1880 the United States produced 3,800,000 tons of pig iron; last year we produced 23,000,000, a little over six times as much as a quarter of a century ago." This is everywhere accepted as one of the most marvelous growths in industrial history. And yet it is not to be compared with the growth of the manufacture of Portland cement. The creation of the Portland cement industry is one of the wonders of the industrial world. In 1880 the total output of Portland cement was 42,000 barrels; last year it was 34,000,000, or over 800 times as much; while pig iron during the same period was only six times as much. This would indicate that we are only at the beginning of the development of this great industry, which, while the rate of growth cannot continue at the same per cent of increase as for the last one-fourth of a century, will, in all probability, continue as great in the actual figures of advance as of late years. The greatest increase has been made in the six years just past. In 1900 the total production was 8,400 barrels; in 1901, 12,700,000; 1902, 17,700,000; 1903, 22,300,000; 1904, 27,000,000; 1905, 34,000,000, and the estimate for 1906 is 50,000,000 barrels. In spite of this stupendous expanse, probably never equalled in the history of any other industry, the demand has been equal to the supply and no manufacturer has had to make a financial sacrifice to market his product. It is also worthy of notice that while natural cement increased in volume of manufacture from 1880 to 1904, 140 per cent, Portland cement increased over 32 times as much.

We have spoken of its growth in the way of volume, now a word about its growth in the way of area. American Portland cement was first manufactured in the Lehigh valley in Pennsylvania. At that time no one supposed that there was anything west of the Allegheny mountains from which Portland cement could be made. It was soon discovered however

that The Star of Empire was not the only thing that "westward takes its way." We find the manufacture of Portland cement pushing its way in the same direction, until today cement factories are found in almost every state in this great union. Our own state, usually to be found in the van on all up to date matters, has almost relegated herself to the rear in this particular, but she has finally awakened and joined the ranks of cement-making states, and if no accident should intervene, before our fourth annual convention is held, Iowa will have at least one cement plant in operation turning out as good an article as is manufactured in the United States, besides other factories in course of construction.

When Portland cement was first introduced into this country its use was confined almost entirely to foundations and cellar floors and the construction of cisterns and reservoirs. As it was almost all an imported article, the price was so high as to almost prohibit its use for ordinary work. But times have changed. A late report shows that we have imported only 6000 barrels this year and that 3500 of those are in the hands of the dealer. We no longer have to depend on England, Germany and Belguim for our cement supply. We have it at home in large quantities, as we have already shown, and of better quality than the imported article.

A few years ago a cement sidewalk was considered a luxury that only the wealthy could afford, but the development of the cement industry at home has brought the expense within the reach of all, so that it has now become the popular walk. It costs but very little over the price of an ordinary wooden walk, no more than brick, one-half as much as sawed stone, and is better than either. It is no longer confined to the city nor the homes of the wealthy. You can find it in every town and hamlet as the rule and not as the exception. Our city of Grinnell has constructed almost ten miles of cement walk in the past two years, and I presume we are no exception.

And now comes the concrete or cement block which we think we can claim as the result of a modern idea. We have some account of attempts at this kind of construction in England in the fifties and in the United States in the eighties of the 19th century, but it was not until 1900 when Harmon S. Palmer invented and perfected the modern block machine that the concrete block gave any promise of universal adoption. As far as I have been able to discover, the Palmer machine was the first to be placed on the market. Then followed the Normandin, the Winget, the Hayden, the Miracle, and then a host of others that I can not name. It was this feature of the industry that I might say has almost amounted to a 'craze.' The cement

block machine has preempted the 'territory from the Atlantic to the Pacific and from the Lakes to the Gulf.' The exhibits made at the St. Louis Exposition in 1904 gave the people some idea of the magnitude of this new industry, and in my humble opinion did more to break down the prejudice of the devotees of the "old system" than anything that has occurred.

It is a very easy matter for one to procure any kind or style of block that he may desire. Nearly every block machine manufacturer has his specialty. We have the two-piece block, the hollow one-piece block, the double air space and the staggered air space, etc. When the block came upon the market it was first used for foundation walls, then for small buildings. Then the factory building, then the store building, then the church, school house, college, hospitals, etc.

By this time the prejudice that was in evidence everywhere among the old architects and builders as to the use of this new building material had begun to diminish, and some of them began to admit that this material had some *merit*, and if properly handled could be made into a substantial building. But now comes the man who is contemplating the erection of a palatial residence for his family to live in. He is prepared to expend a large amount of money and he wants the best, and he wants to be sure that he makes no mistake. He is told that this material has not been sufficiently tested, that he had better build of wood, but he objects to wood because it needs to be painted so often and that is troublesome and expensive. Well, try brick. But brick so soon get dingy and the walls get damp unless furred and lathed. Well, what about stone. Oh, stone is all right, but cutting stone for ornamental work is very expensive and a stone wall is so dead, no insulation, and so he comes back to investigate the cement question, and what does he find? He finds that cement stone costs very little more than wood, needs no paint, increases the comfort of his family, and cuts down insurance and fuel bills. As compared with brick, it costs no more than the cheapest kind of brick, and it needs no furring or lath. As compared with stone, it can be constructed at one-fourth the cost, and has the advantage of a hollow, insulated wall. As compared with competitors, it stands head and shoulders above them all in that it is warm in winter, cool in summer, fashionable, durable, and ornamental.

Now, while concrete in the form of a block has proven a success in the construction of the various buildings herein mentioned, there is one class of buildings for which the concrete block has been considered inadequate. I refer to the modern office building which has become so common in recent years in our large cities, known as the "sky scraper." The demand for

this class of buildings was so great and steel for their construction so hard to get, which made the work of construction so slow on account of so many long waits for material, that something else must be found for the skeleton. This led to the introduction of reinforced concrete. This form of concrete construction seems to hold a field peculiarly its own, and no form of construction has made such rapid headway since its introduction as has this.

I will mention only two examples of this form of building. The first is the new Commercial Building at Pittsburg, Pennsylvania. This building stands on a prominent corner in the wholesale district. It is eight stories high and built entirely of reinforced concrete. In eighty-two days from the time the foundation was started the roof was on the building. The force of workmen employed numbered from twenty-five to forty, about one-half the time was required as to construct the same sized building with the steel frame. The cost of the building was $125,000. A test of this building showed that the floors had a carrying capacity of 250 to 350 pounds to the square foot.

The other example I will mention is the Ingalls Building in Cincinnati, Ohio. When the contract was signed for the erection of this building old architects and engineers shook their heads and looked wise. They said the thing was impossible and would end in disaster, but the building kept traveling skyward until it reached the height of 200 feet and still the "mud columns" and "mud beams" and "mud arches" for floor spans remained intact. After the building was finished and before it was turned over to the owner, it was subjected in detail to the most rigid tests ever applied to any large building, and it was found that every beam and span proved a factor of safety far beyond anything which it would be called upon to carry in the ordinary use of such a building. And so the prophecy and predictions of the 'wise acres' fell to the ground, but the building still stands.

I have already taken too much of your time, and have only started to tell you of the possibilities of this wonderful material. The time would fail me to tell of the fence posts, the railroad ties, the culverts, the bridges, the sewer pipe, etc., etc. Gentlemen, we represent here today the greatest, the very greatest industry in the commercial world. Yes, we challenge the wide world to show up any industry whose development and utility will compare with American Portland cement.

President Bingham: We are now free to take up any subject for the remainder of the evening. If any one wishes, an informal discussion. If any one has any questions to ask, any information that he would like to have, we can just as well spend three-quar-

ters of an hour or so in discussion. Doubtless most of us here have come with the purpose of asking some questions, getting some light on some particular line of work. We would be glad if some would ask these questions now, or would suggest some topic for a general discussion.

Question. Some of us were asking this afternoon about the matter of shrinkage of sand, as we ordinarily use it; that is, how many cubic feet of packed concrete would an ordinary yard of our loose sand make. Now, if any here have had results along that line, have made any tests, know what the average shrinkage is, I am sure the rest of us would like to hear from him on that point.

Pres. B.: That is certainly a thing that a body of cement users ought to know, and somebody has certainly made a test. Mr. Coutts, what do you know about it?

Mr. Coutts: I didn't suppose I was going to be the only one to talk here. There are a lot of men who know more about it than I do. My experience has been that a yard of sand will block 22 cubic feet, but I have been on the floor for some time, and I want to hear somebody else talk. Of course we are talking about our average river sand and gravel, and not of any ideal mixture.

Pres. B.: Has any one else had a different experience?

Answer: I have found it to make from twenty-two to twenty-three feet.

Pres. B.: Compares very nearly with Mr. Coutts' experience.

Mr. G. Keil: Mr. President, I would like to ask what constitutes a yard of sand; is it measured at the bank or as it is shoveled on the wagon and left there loose before being shook down; or is it considered to weigh so much? Now what brought up this question was, I got into a little trouble with our sand hauler in Minnesota. He didn't want to put on a full yard of sand at the bank, and I told him I wanted a yard of sand at the factory.

Pres. B.: The question is, what is a yard of sand or gravel? So far as my experience goes, it has been what would make a yard when shoveled loose on the teamsters' wagon. Now if others have had a different experience, have considered that it requires compacting before it is considered a yard, we would be glad to hear from them.

Answer: There would be no use in weighing the sand, because wet sand weighs less than the dry sand.

Pres. B.: I presume it weighs more when it is dry unless it becomes very wet.

Mr. J. M. Johnson: I would like to ask a question. Would

it make considerable difference in the quantity of sand that is necessary to make a certain amount of concrete whether you used ordinary sand, or sand mixed with crushed rock? Would not sand and crushed rock sink considerably more, because the rock would take up considerable room, and the sand would naturally fill in the space between the pieces of crushed stone?

Mr. C. B. Roman: My experience has been that the coarse material will pack pretty nearly ten per cent more than fine sand.

Pres. B.: This coarse material will pack ten per cent more than loose sand? That is when you have coarse material by itself?

Mr. Roman: No, I am talking about gravel. I use Mississippi river gravel.

Pres. B.: Does that answer your question, Mr. Johnson?

Mr. Johnson: Yes, partly. I had reference more to crushed rock and sand mixed, whether it would not settle and shrink more than if you use sand alone?

Pres. B.: Will some one please explain that point in answer to Mr. Johnson's question? Have you found that the shrinkage is greater with the coarse gravel or with gravel and crushed stone than with fine gravel and sand alone?

Mr. Coutts: Mr. President, I might say that, if I use crushed stone or gravel, I figure that the cement and sand put into it is all shrinkage, because the cement is intended to fill voids in the sand. Of course you take a mixture of 1 to 3 to 5, which is the proportion for concrete work, and you put 5 parts stone, 3 parts sand, and 1 part cement.

Pres. B.: Mr. Coutts, was your experience in regard to the shrinkage the result of such a mixture as you now mention?

Mr. Coutts: Yes sir, 1 to 3 to 5 won't shrink as much as the other.

Pres. B.: 1 to 3 to 5 will shrink only 3 or 4 feet whereas the mixture of sand and gravel will shrink to twenty-one or twenty-two cubic feet, has been your experience?

Mr. Coutts: Yes, sir.

Mr. P. P. Comoli: This question of shrinkage certainly all depends on the mixture.

Pres. B.: I understand that you are speaking of the shrinkage as it depends on the dampness of the mixture used.

Mr. Comoli: Well, the question brought up was the amount of shrinkage of gravel. Of course the water would have a great effect on the amount of the shrinkage measuring the concrete after it is mixed, and it depends almost altogether on the amount of moisture.

Pres. B.: I would like to hear some more experiences as to how much compacting is brought about; how much the shrinkage

is in compacting the average loose sand and gravel. Unless we hear some further experience, we will have to take what has already been said as gospel until we are corrected. Twenty-seven cubic feet of average coarse natural mixed sand and gravel, make twenty-two cubic feet of concrete. I wish there were more who had a report to offer. Well, what is the next point?

Mr. Chairman, my name is Mershon: I am a farmer from near Newton. I don't pretend to know anything about cement work. I am here for information. I have an abundance of fine sand that I can work at home. I wish to ask whether it would be all right to use that fine sand, or whether it would pay me to buy coarser sand or gravel to put with it.

Pres. B.: About what sized sieve would your sand pass?

Mr. Mershon: I could not say. The sand is not very sharp and is a little too fine to do a good job of plastering.

Pres. B.: And what would your other material cost?

Mr. Mershon: Ten cents per bushel. Would have to haul it eight miles, one hundred and ten pounds to the bushel.

Pres. B.: My opinion is that it would be a matter to be decided by a test of your sand, whether it would cost more to get the additional coarse material to go with your finer sand, or to buy sufficient cement to use it as it is.

Mr. Mershon: Then it would take more cement with fine sand than it would with coarser sand?

A. Yes sir.

Pres. B.: We would like to have some one else—

Remark: Sand too fine to do good plastering will never make good blocks.

Remark: I have seen some very satisfactory ones made with fine sand.

Remark: If you put enough cement with it.

Mr. Jas. McCoy: My experience is that fine sand will not make good blocks. You cannot put cement enough in it to make blocks that will stand. I have tried it to my satisfaction, and the gentleman would be ahead if he wants to do cement work, I think, to haul that coarser material. I do not think sand too fine for plastering is good for blocks, or should be used for blocks.

Q. Do you use the dry system of making blocks, Mr. McCoy?

Mr. McCoy: Yes sir, that is, just moistened, we work it dry.

Mr. H. C. Shadbolt: I know a building that is made from very fine sand, so fine that you can hardly contain it in a flour sack, and I am sure that it has a very neat appearance, and looks as if it were going to stand. The blocks were made as they told me, four parts sand to one of cement. The structure stood nearly three years, and no moisture had appeared they said on the

inside of the house, which naturally would occur if the sand were of a coarser nature. That experience with fine sand certainly goes to show that it can be used to a certain extent.

Pres. B.: Was it made by the dry system?

Mr. Shadbolt: Yes, by the dry process.

Pres. B.: There is a conflicting report as to the use of fine sand. Let us have more experiences.

Mr. Shadbolt: This house was of one story, but what weight such blocks would carry in a three story building, I cannot say, but they certainly were a success for the work they were called upon to do.

R. You can build a one story house out of very poor soft brick and it will be fairly substantial. I do not believe a block of crystallized cement mixed with fine sand, would be satisfactory for a building of any height.

R. I would sooner take my chances on a building block 8 to 1 out of coarse material than to make it 3 to 1 out of fine sand.

Pres. B.: Has any one else had experience in the use of fine sand, in making blocks or any other concrete work? Have you made good strong work?

Mr. R. E. Lynn: Mr. President, I had a little job of pier work three years ago, made with sand so fine that we could hardly get the cement mixed with it. We put the piers about eight feet apart, center to center. I have examined it several times since, because I was a little fearful of it at first, and they seem to be as good as any blocks I ever saw. I don't see why, if fine sand is thoroughly mixed with cement, it won't make just as good a block as coarser sand. It is not altogether in the sand, but the way you get it mixed. Fine sand is much harder than coarse sand to mix thoroughly, so as to get the particles completely surrounded; but I believe if properly mixed, it will become in time as hard as a coarse sand mixture.

Mr. E. Kenney: I suspect the gentleman, having the fine sand on hand free of cost, would be justified in using fifty per cent cement without any serious injury to the work.

Pres. B.: I would suggest that a number of tests have been made here, of the strength of concrete made out of different materials, and doubtless many of the different samples have been made out of fine sand such as you have on hand. During the convention there will be a paper presented on sand by Mr. Reinhart, who has had charge of some of the testing work and who can probably answer your question in an authoritative way. Has any one another point to bring up?

Prof. G. W. Bissell: Mr. President, I have a problem of an entirely different nature, but still a concrete problem. As you

entered the grounds, you saw a new building, the new power station. The roof of that building is well trussed with slabs of reinforced concrete, and will be eventually covered with tile. The concrete is a cinder concrete, and put on in the month of December. As you remember we had various kinds of weather, and although all possible care was exercised to see that the ingredients were free from frost, and that salt was used when the weather seemed to require it, still we are a little bit dubious about that concrete, and we wonder whether we are needlessly so. We are on the safe side, however, as far as the expense of the work is concerned, and I have agreed with the contractor that the cinders shall not be removed or the tile placed on the outside until summer time, and then we will know. I have not been able to get an opinion from anybody who has had experience with just this kind of concrete work. There is a great deal of data on record, I understand, pertaining to concrete blocks on the ground, and the trend of opinion seems to be that even if they are put on the ground, so long as it is not cold enough that the blocks freeze, they will be all right, but here is a different case. It has not been possible to prevent them entirely from freezing. The under side of the roof has been kept warm enough so that the frost did not show, but one side has a southern exposure, and one a northern, and blocks or little chunks of cement or concrete have been taken off and some found to be frozen We feel, as I said, a little dubious; now, how should we feel about it? It is a reinforced concrete roof, slabs five inches thick, with one-half inch joints, and bars seven and one-half inches apart.

Pres. B.: Professor Bissell has brought up an interesting point. If any one present has had any experience with concrete exposed in that way, we would be glad to hear from him.

Mr. Comdi: Mr President, I would like to ask the professor how long ago this was done; I didn't understand.

Prof. B.: It was done during last month.

Mr J. C. F[illegible]: Mr. Chairman, my experience in this [illegible] that sometimes concrete stands and sometimes it [illegible] depends a good deal on the cinders. If cinders are [illegible] there is no reason why it should not stand [illegible] if they were not thoroughly vitrified, there is [illegible] cinders that will slack. Some time ago, the [illegible] A man offered to give me some cin[illegible] into the sand. I got a load of very good [illegible] made some cement blocks. I lost them all. [illegible] cinders had been thoroughly vitrified they [illegible] The cinders expanded and just sim[illegible] the different parts of the [illegible] all to pieces.

In the Montrose hotel in Cedar Rapids, they used cinders, and I believe seventy-five per cent of it was put in in November, December and January. At least fifty per cent of the cinder concrete had to be taken out and replaced with stone concrete in the spring. In another building in Cedar Rapids cinder concrete was used, done about this time of the year, and that stood all right. So far as I know, it all depends entirely upon the quality of cinders used. It is very risky business, as far as my experience goes, to use cinders for concrete. If the cinders are in just the right condition, you will have good work, but if they are not, if the material shrinks or disintegrates, it will spoil your concrete.

Pres. B.: What in your judgment would be the reliability of the roof Professor Bissell spoke of had it been made of hard stone concrete, and subjected to the same changes of temperature?

Mr. Fulkerson: I have thought until this fall there was no danger in doing concrete work in cold weather. I have put in concrete work in the coldest weather, did some work when the thermometer was fourteen degrees below zero, and had apparently no bad effects. This fall I became of course very bold from having such good results, and I put in three culverts for the county, believing that frost did not have anything to do with it. It didn't worry me a bit, because of my former experience; but now I wish it had. These culverts are all skinned off, and they just look horrible, and I haven't been able to get my pay for them. I think the cause of their scaling off was not from the freezing, but from the thawing. It froze every night, and thawed every day. My advice is, don't do it in the winter time.

Pres. B.: That brings us well into the question of concrete work in freezing weather. Certainly that is something we are all thinking about, as soon as it begins to freeze in the fall. Shall we or shan't we? How shall we finish up what is necessary, or are we warranted in attempting new work?

Mr. Carlon: Mr. President, I have had quite a good deal of experience in doing cement work in freezing weather, and have found that if cement can set from eight to ten hours, I never have any trouble with frost. I remember one job especially five years ago. We put in a sidewalk, about a sixteen foot walk. Commenced in the morning at the building, working out toward the curb. The work was put down in three foot strips. It froze that night about four inches deep, and every one is perfect except the last strip. I had quite a job this fall in December building a large tank. I covered it, protecting it about twelve hours, but I have had no trouble after eight or ten hours setting. If the cement freezes in setting, I have always had trouble.

Pres. B.: You have had experience, Mr. Carlon, in freezing and thawing alternately, after the eight hours?

Mr. Carlon: Yes, sir. My experience has been that after it has set, the frost will not hurt it any.

Pres. B.: Any further experiences on this question?

Mr. Kenney: I have had some little experience with stucco. You can tell very readily when the set takes place. It is instant and final. If you freeze stucco previous to the time it changes its color, it is ruined. If cement is frozen or dried previous to the final set, which I think takes a good deal longer time than is usually given, it is injured. They say about five and one-half hours, but I don't know that the final set has taken place in that time. After twenty-four hours have passed, there is no great danger.

Q. How was it those culverts froze, within eight hours after they were made?

Mr. Fulkerson: I don't know. My former experience had been considerable; I had built walks, and had them freeze up; never hurt them, and I had done most everything else, but this was the one time; I don't know what happened; I wasn't there.

R. I have found out that if sidewalk blocks freeze the first night after they were made in the afternoon, they just crumble and break all up; but afer twenty-four hours, I have never had any trouble. If they freeze in the first six or seven hours, they are spoiled, the cement never crystallizes at all.

Pres. B.: Your experience concurs with Mr. Carlon's, that if the freezing is delayed until after what you might call the set has taken place, there is no danger?

Mr. Comoli: Mr. President, this problem of freezing concrete, is like putting cement on smooth surfaces; everybody has his own opinion. I have seen concrete frozen, have seen it turn soft again the next day, and afterwards set as hard as anything. Sometimes it will come out all right, and again it will come out all wrong. I have made up my mind that when freezing comes I will quit.

Pres. B.: It is doubtless a fact that good results have been secured in freezing weather; we ought to know how these good results were obtained, and why poor results were obtained in seemingly similar conditons. If good work has been done, good work can be done, and we want to know how to do it. We would like more light on that; if anyone can explain why some work fails, while some is successful, in seemingly same conditions, we would like to hear from him.

R. Mr. President, I have had a good deal of experience in concrete work freezing. If it freezes after the water has settled, no harm will result, but if it freezes with the water in it, the con-

crete will never be good. I had a piece of sidewalk freeze, and stay frozen all winter. It had settled enough so that the water was pretty well out of it, and in the spring when it thawed out, that piece was soft. I thought then we would have to replace it. It seemed however to have set enough so that the frost didn't stop the process entirely, and it became very hard.

In regard to the roof, I think if the concrete has remained firm and solid, it will thaw out and get just as hard in time as if it never froze. It may be soft, but if it has not separated in any way, and doesn't show any sign of scaling it will finish the setting process and get just as hard as though it had never frozen.

R. I find that the amount of moisture in the cement at the freezing time has a great amount to do with the effect afterwards. If there is more water, it will cause it to freeze harder. That is one reason why some work will turn out all right and others will not.

Pres. B.: That is doubtless a very important reason. But it does not solve the difficulty.

Mr. J. N. Muncey: I have noticed a walk that a carpenter built late in the fall. He quit about three or three-thirty in the afternoon, and it froze very hard that night. I cannot give you the temperature, but I know it froze hard. The carpenter was convinced before he had seen it that the sidewalk was destroyed. Well, I pass over that walk, it has been made a year, two years maybe, and it seems to be all right, except on the end where he began in the morning. The top he floats on, just as I believe most men do, and the lower part not so soft.

Pres. B.: Thank you. If no one has anything further on that topic, I guess we had better close for tonight. A number of those present were either up pretty late last night or had their sleep broken in coming, and we want to get a good night's rest, and be prepared for a full day tomorrow. We will stand adjourned for this evening.

SECOND SESSION

Thursday Morning, January 24, 9 O'clock

BUSINESS SESSION

President Bingham: The first thing on the program for this morning is the appointment of necessary committees, those on resolutions, nominations, and legislation. Now, how will you have these committees appointed?

Moved and seconded that these committees be appointed by the Chair. Motion carried.

Pres. B.: By your leave, I will postpone the appointment until we have the reports of the committees.

We have first, I think, the committee on legislation, who were to report at this convention. Mr. Coutts of Grinnell was chairman. We are ready to hear from that committee.

Mr. Coutts: Mr. Chairman, I confess I forgot all about my being chairman of that committee, and more than this, that the committee was to report this morning. I have not prepared for it at all, but I can simply state in a few words what the committee has done. A short time after the last annual convention, the members of this committee met in Des Moines with the committee appointed by the State Brick and Tile Association. This meeting was, I think, in February, at the time the legislature was in session, and a bill was drafted, of which Mr. McHose, the chairman of the Brick and Tile Association committee, was placed in charge. That bill, providing for the establishment of a department of ceramics at the Iowa State College, was prepared and presented to the legislature. I think that Professor Beyer will be able to tell you something about what the bill consisted of. He was present at that meeting of the committee. I took this up with our home member of the legislature. This bill was adopted by the legislature.

I wrote the congressman of the Sixth district regarding the bill that was pending in congress voting aid to the different colleges in the west, and continuing support of the Government Testing Laboratories at St. Louis, and received a long letter from him, assuring me of his interest in the bill, and of his aid in pushing it through. I also received a response to a letter I wrote to the Speaker of the House, stating that my communication had been received and would receive the attention that it deserved. I afterwards received a letter from Mr. R. L. Humphrey, who is president of the National Cement Users Association, stating that congress had passed this measure. I am sorry to confess I have filed all this correspondence, intending to bring it with me to this convention. In my hurry I forgot it, but have mentioned the substance of it I believe.

Pres. B.: Is there anything in addition to this report?

Prof. Beyer: Mr. Chairman, I do not happen to have a copy of the bill mentioned by Mr. Coutts, but I think perhaps I can give you the substance of it as it relates to the work to be done at the college. The lateness of the meeting of these committees seemed to make it advisable to draft a bill to be considered favorably in the short time intervening before the adjournment of the legislature. The original bill not only provided for the establishment of a department favorable to cement users, but it also included an appropriation for the establishment and maintenance of such work. It was deemed advisable, however, on account of the few weeks intervening before adjournment to

modify the bill somewhat by striking out the clause which would provide for the carrying on of the work. So the bill as passed provided for the establishment of such department, but nothing for its equipment or for its support.

Pres. B.: I will now appoint the several committees. On legislation, will continue the two members present already on that committee, viz., Mr. Coutts of Grinnell, and Mr. Carlon of Oskaloosa, and will add thereto Mr. J. C. Fulkerson of Cedar Rapids. On resolutions, D. P. Faus of Waterloo, J. N. Muncey of Jesup, Wm. Stewart of Armstrong. On nominations, Prof. Beyer of Ames, E. Kenney of Creston, H. C. Shadbolt of Emmettsburg.

Pres. B.: We will now have Professor Beyer's paper on

CEMENT MANUFACTURING PLANTS OF THE STATE

Mr. Chairman, Gentlemen of the Convention: I want to disabuse your minds in regard to the title our president has given what I may have to offer. The committee on communications requested that I should give some information in regard to the progress which has been made in the building of cement plants during the current year. All I have to give may be considered in the light of a progress report.

Perhaps it might be well for me to first tell you a little about a Portland cement plant and some of the processes necessary, in order that you will understand better the progress which is made in the building of our plant. Of course I will have to ask those of you who know much more about Portland cement plants than I do to bear with me in this, but I assume that there are a good many here who have not had the privilege of visiting a Portland cement plant, and are not familiar with the numerous processes and detail that bridge the gap between the raw materials and the finished product. In the first place, most of you I take it, know from the exhibits in the hall, that Portland cement is a product made up of limestone on the one hand, and shale or clay on the other. Sometimes in place of limestone, marl is substituted. In our own state, we have no marl deposits, and are obliged to use limestone and shale, usually mixed in the proportions of 3 or 4 to 1. I am of the opinion that that made at Mason City will be about a 3 to 1 mixture. These materials are first quarried or mined, passed through crushers, then sent through pulverizing mills of the Griffin type, then through ball mills where it is ground fine enough so that the bulk of the material will pass through a 200-mesh sieve. There these materials are mixed in their proper proportions, and delivered to the kiln.

The so-called rotary kiln seems to be the most generally accepted type. It is a cylinder eighty to one hundred and twenty feet long, and six to eight feet in diameter. The shell is usually constructed of heavy iron, and lined with fire brick or other refractory material. The raw materials, after they pass the grinding machinery, enter the upper end of the kiln, which is set at a slight incline. The kiln is mounted on wheels, and caused to revolve slowly. The raw mixture enters the upper end of the kiln, and, on account of the rotation, gravities slowly toward the other end. The fuel enters the lower end of the kiln. Before the materials reach the lower end of the kiln, they are fused into a sort of natural glass. As this glass is discharged, it is chilled by spray of water, and the product is called the clinker. The clinker goes through the same general pulverizing processes as before burning. The bulk of the final product must pass the 200-sieve. It is then taken to storage bins for curing, and finally to the establishment where it is sacked or barreled, as the case may be, and ready to put upon the market.

Some of you think that the price is pretty high, but I wish you would remember the difficulties encountered in manufacturing the product. The statistics for 1904 show the average price per barrel at the factory to be $1.00; $5.00 per ton. All this must be done for $5.00 per ton, and include profit.

Most of you were probably aware when we met a year ago, that options had been taken on certain lands near Mason City, with the idea of building a plant in the near future, providing the conditions were favorable. These options were closed, and the company organized. I want to tell you that I am not advertising any Portland Cement company that exists, now or prospective, but I have here the prospectus of the plant that had started a year ago. They are incorporated under the laws of West Virginia, have an authorized capital of $1,750,000.00 preferred stock, and a like amount of common stock. This company is organized as the North Western States Portland Cement company, and in a way is a branch of the Western States Portland Cement company.

This first plant started out to take options and buy land. They have bought all the land they think they will need for several decades, also a good deal that they thought competitors might want. This plant is between the Iowa Central, and the Great Western and Northwestern railways, and of course the interurban or Mason City and Clear Lake railway gives switching connections with the Milwaukee.

The building of the plant commenced with the putting up of houses for the workmen, and a hotel for the foremen and superintendents and office force. After that they started on the

plant proper, and at the present time, have gotten along to the construction of one of the large kilns. The dimensions of the kilns they are putting in, I find, are one hundred and ten feet long, seven and one-half feet in diameter, and weigh seventy tons each. They contemplate installing twelve of these, and expect a capacity of four to five thousand barrels a day.

The Northwestern States cement plant is not the only one in the field. They had scarcely closed their options before a second company appeared on the scene, the Iowa Portland Cement Company, organized in August of last year. This company has options and has purchased a half section of land some little distance east of the first plant. They have already built a stub from the Milwaukee railroad, and have started to build cottages for the workmen, and to put up a hotel building for their office force. On account of cold weather coming on, they have abandoned the work until spring.

A third company is also in the field, the Lehigh Portland Cement Company. They have bought some land and expect to build a plant, providing they can obtain good title to some of the property under litigation at the present time.

I do not know but I can best illustrate Iowa's position, or what it will be, in the cement world in the near future, by telling a mother-in-law story. Mother-in-law stories are a little chestnutty, but with your permission, I will spring one. Two Irishmen happened to meet on the street, and one of them was going on "This is a hard, hard world." The other one said, "Mike, what's the matter with you?" "O," Mike said, "I have lost my mother-in-law. It's hard to lose one's mother-in-law." "Hard?" said the other. "Bejabers, it's almost impossible." I want to say that within a few years, it is going to be impossible to lose Iowa in the manufacture of Portland cement.

Pres. B.: The next subject will be taken up by Engineer A. J. Lilly, of Algona.

THE USE OF CONCRETE TILE FOR FARM DRAINAGE

In attempting to outline the subject "Concrete Tile for Farm Drainage," I looked through the pages of books and magazines by the various writers on concrete and could find it used for the construction of cisterns, tanks, well-curbs, horse blocks, silos, culverts, and many other things pertaining to the home and farm, but failed to find more than a suggestion that cement might be used for tile, leading me to believe that the writers on concrete, all live in a well drained part of the country.

This being the fact, it would be presumption on my part to attempt to enumerate the causes or failures in the concrete tile industry. There are many theories as to what the concrete tile

[illegible] will not do, when put to the test, so I shall [illegible] the subject from my own observation in the [illegible] the light I may give, coupled with the ex- [illegible] may penetrate far enough into the future [illegible] tile industry to enable us to take a positive stand [illegible] merits and demerits of concrete tile used for farm drainage.

The question now before us is, what do we have to overcome? [illegible] of the great obstacles in the way, especially [illegible] is prejudice. I well remember the first con- [illegible] The tile was a 15-inch, about fifteen days [illegible] in the shed with the finished products. I took [illegible] to tip it over on its edge and a piece about four [illegible] came out of the side. I immediately got out of [illegible] more of them might fall down and I would be [illegible] the destruction of the entire lot. This incident set [illegible] thinking and investigating. Other men with somewhat [illegible] experiences proceeded to publish it as a fact that all [illegible] are unsafe to use for farm drainage.

[illegible] to show more clearly the inconsistency of these [illegible] we must take into consideration the fact that the clay [illegible] has long been in use and the defects have become [illegible] known that they pass unnoticed. For example, take a [illegible] with a piece out of its side. They say, "That's all right, [illegible] the broken side down." A crack in the clay tile, "Oh, [illegible] just as good as any after it is in the ground." Still another defect is common to the clay tile. After a little exposure they are apt to come apart in layers or scale off, but they say, "That won't hurt them any, they will stand after they are in the ground." But it is altogether different with this newcomer, the concrete tile." It has been condemned already in the minds of these critics and since there is so much more expected of concrete tile than a clay tile it will have to win a place in farm drainage on its merits. Almost any make of clay tile can be piled in the yard and but few or no criticisms offered, but if the same rigid inspection was carried on against the clay tile as against the concrete tile, many of the clay products would be among the condemned.

The question naturally arises as to what caused this talk against the concrete tile in this locality. To begin with a fifteen inch [illegible] was purchased and a few tile made. These sample tile [illegible] with a proportion of 1 to 3 and the tamping [illegible] carefully done, the natural result—a [illegible] expectations and praised by everybody. This [illegible] idea that concrete tile could be made and [illegible] and be used as soon as old enough to be

handled. Various methods or theories were advanced as to the handling of green tile. The specifications for the concrete tile were 1 to 3 and water at least six days and cure about twenty-four days more before putting in the ground. It was finally decided to make the tile along the ditch and cure according to specifications. This was in the fall of 1905. Cement was ordered and stored, sand hauled along the ditch and everything ready for the spring work. In April, 1906, molds were purchased, cement hauled out and the work of making 4,000 18-inch tile commenced.

Up to this time a *good* tile was all we knew about but as the work progressed I soon found it necessary for me to know how to make and judge a *poor* tile. Not only do we find the same, but more, difficulties to overcome in making tile in the field than in the factory. It is a difficult matter to get men on whom you can depend to do good work. Too often the efficiency of the laborers is measured by the location of the "boss." If a mechanical tamper could be used, the tamping would be more uniform; but out in the field where hand tamping is necessary and a solid foundation is lacking on which to tamp, the tile made up to about three o'clock p. m. are more uniform than the tile made from that time to the close of the day. You frequently meet with cases where the shoveler becomes careless and dumps too much concrete in one place. This is quite sure to show up in the finished product and may condemn it. In removing the mold, sometimes a piece is knocked out of the tile. To make the tile appear finished the piece is troweled back but this always leaves a blemish and as a rule the tile should be knocked down and used as sand in making other tile.

The next important part of the work after the tile is made and the mold removed is the watering. This is too often left to inexperienced men or boys while men of experience tell us they cannot trust that part of the work to the most *careful* man on the job unless under their personal supervision.

The tile made along the ditch were exposed to the wind, rain and all the sunshine we had, no covering used at any time, although I maintained that a covering of slough grass would be very beneficial. In a short time after the mold was removed, the tile would begin to turn white at the top and then it was ready to take up from five to eight quarts of water. This was repeated several times a day depending somewhat upon the condition of the weather. These tile stood on end and the water was applied by hose or sprinkler but you can readily see that the top of the tile absorbed very little moisture under these conditions. The lower half of these tile in most cases was more solid than the upper half because of the excess of water and the mois-

ture received from the ground. In some cases this difficulty was partially overcome by upending the tile and giving the spongy end the benefit of the ground moisture.

The best curing process we found in the field was to roll the tile into the slough as soon as they could be handled. In some cases the tile were entirely submerged and in other cases about half. In the last named condition all that had to be done to water the tiles was to turn them over which was a very simple thing for an experienced man. Even with this convenience of watering, a number of tile were spoiled because of a thoughtless employee taking hold of a green tile and giving it a quick jerk, breaking a piece out of the end. But other than such breakage, these tile stood the inspection by throwing out about ten per cent, while other lots had from fifteen to thirty-five per cent discarded.

There is another important point to be considered in making tile in the field. Usually there is stock in the pasture and almost any animal is curious to know what is going on and must necessarily rub against a few of the tile to try them: also, the tile are subject to examination by the passerby which is not always the best thing for the contractor.

In making these tile the Atlas cement was used and to my knowledge no test was made. I knew nothing of what was being turned out as a finished product until the tile were ready to be laid in the ditch when I was called upon to inspect them. This was the first I knew that concrete tile were a complete failure and ought not to be put into the ground. I inspected 3,200 concrete tile, 15-inch, and they were laid. At this stage of the game no man's opinion was any good unless these tile were condemned, because if a favorable opinion was given it would be said of him, "he did not tell what he thought." It was, and I believe is yet, thoroughly believed by some that if these tile were put into the ground they would disintegrate and the efficiency of the drain would, in a short time, be entirely destroyed.

Now, since these little tile were laid and did not disintegrate, the last theorist comes with the new idea that where concrete tile are used they fit so closely at the ends that the concrete will set and make one continuous line of pipe and therefore shut out all the water except where junctions are made. I have a report of recent date from a land-owner having land adjoining a large slough drained, last fall, by these 15-inch concrete tile and he stated that all of the water was out of the slough and that to his knowledge the tile were working all right. I also have a report from a man having quite an extensive experience in tiling and superintending the laying of several car loads of concrete tile made by machinery. He reports very favorably on the use of concrete tile for farm drainage. He further states however that

if he had his land tiled with clay tile he would be more pleased. He reports also a car load of 4-inch shipped about thirty-five miles and a breakage of thirty-three and one-third per cent which cause quite a little talk against the tile. But investigation showed that the tile loaded into the car were but four days old and that afterwards other tile were shipped with a very small per cent of breakage.

Now another man with a similar experience with clay tile, but no knowledge on the practical use of concrete tile other than having examined a certain machine, gave his opinion that the *slush* tile, as he calls them, are too porous. However, he admits that the porosity is all right, but thinks the tile will not stand. The machine-made tile he therefore condemns, but favors the tamped tile, because if made right, "you know you have something durable."

Now since the concrete tile are on the market and are here to stay, what are to be the most profitable sizes to make? A recent report from one factory on the output of machine-made tile shows that a greater labor cost is entailed to make 2,000 4-inch tile than to make 2,000 12-inch tile. It also shows that on the 4-inch tile at $20.00 per thousand the company lost money; on the 5-inch at $24.00 per thousand they broke even; and on the other sizes up to a 12-inch tile, the largest size the machine will make, they made a good profit. This reveals to us, the fact that the capacity of the machine must be increased or we must reduce the running expenses of the factory; or else, we are to educate the public to use nothing smaller than a 5-inch tile.

I have statistics showing some accepted competition bids f. o. b. the cars at the nearest station to the work to be done. These bids per thousand feet were as follows: Clay tile, 15-inch, $225.00; 16-inch, $240.00; 18-inch, $345.00; 20-inch, $500.00; 22-inch, $600.00; and 24-inch, $700.00. Concrete tile 24-inch, $696.00; 28-inch, $850.00. I also have quotations f. o. b. cars at the factory per 1,000 feet for the concrete tile as follows: 15-inch, $225.00; 18-inch, $350.00; 24-inch, $650.00; 28-inch, $750.00. Another factory quotes per 1,000 feet as follows: 24-inch, $550.00; 26-inch, $600.00; 28-inch, $650.00; 30-inch, $725.00; 32-inch, $750.00; 34-inch, $800.00; 36-inch, $900.00; 38-inch, $1,000.00.

In studying and comparing these prices I am led to believe that the machine-made tile, either of clay or concrete, up to and including an 18-inch will be the most profitable for the contractor. In cases where fewer tile of the larger sizes are needed for main lines to give proper outlets, some standard mold may be used for all sizes above a 14-inch and this will, as a rule, be the most profitable for the farmer. However, in making these tile

on the farm, great care must be taken in selecting sand and cement, and in mixing and curing, or else we will have more experience at the expense of the concrete tile industry.

In order to give you some idea of the number of feet of tile to be used in the improvements now under consideration, I quote from Drainage Districts No. 4 and No. 7, Kossuth county, Iowa, as follows: Drain No. 4, 20,110 feet of 36-inch; 28,990 feet of 32-inch; 13,700 feet of 30-inch; 9,670 feet of 28-inch; 4,400 feet of 26-inch; 13,900 feet of 24-inch; 6,030 feet of 22-inch; 32,430 feet of 20-inch; 64,270 feet of 18-inch; 49,340 feet of 16-inch; 61,510 feet of 15-inch; 40,588 feet of 14-inch; 140,770 feet of 12-inch; 97,430 feet of 10-inch; 52,890 feet of 8-inch. Drain No. 7, Kossuth county, Iowa, 10,220 feet of 24-inch; 5,800 feet of 18-inch; 5,800 feet of 16-inch; 9,650 feet of 15-inch; 1,700 feet of 14-inch; 30,750 feet of 12-inch; 8,750 feet of 10-inch; and 12,150 feet of 8-inch tile.

These quotations are from but two Drainage Districts out of a possible twenty districts in the same county. Other counties in northern Iowa are in the drainage work in about the same proportion. These figures refer to the main lines only, which means in addition many miles of tile from five to twelve inches in diameter for the laterals necessary to complete the proposed drainage.

These drainage propositions are before us and the only question as to the tile is the supply. In my opinion this is a great opportunity for the development of the concrete tile industry.

In looking over the numerous drainage propositions in northern Iowa, one is led to believe that this industry must soon develop thoroughly and rapidly. The demand for the different sizes of tile is far in advance of the supply. The only question in the use of cement in drainage is that of making *good* tile. The existing prejudices will then be blotted out, and the concrete tile will have won its place in farm drainage.

It has been suggested that some attention be paid to the relation of the drainage engineer to the cement tile industry. I am free to admit that this is a broad subject and shall not attempt to point out all of the duties or relations of the drainage engineer to this industry, but endeavor to treat the subject from my own observations.

In the first place there should be a direct and complete understanding of things as they are, which naturally leads to the exercise of good judgment on the part of the engineer, and forms the basis of practical efficiency. There should be nothing sanctioned in engineering education or experience encouraging a deceptive treatment of things or people.

Many times the drainage engineer is called upon, or placed in such a position by appointment, to pass on important questions relating to both contractor and manufacturer. In some cases, the specifications are written by one who is unacquainted with the work from an engineering standpoint, and the engineer, to carry out these specifications, must use good judgment, or as Trautwine puts it, "Must take his horse sense, if he has any, to the field with him."

It is a very easy matter to discriminate against the concrete tile, because of its recent appearance on the market. The clay product has been in use so long that its defects pass unnoticed. But not so with the concrete tile. Much more is expected of it than of the clay tile. The critic says it must be of even thickness, smooth, have a clear ring, or go to the junk pile.

It is evident that the efficiency and life of a drain depends upon the weakest tile in the ditch. Frequently the engineer is called upon to inspect tile that are made along the ditch. The engineer is simply to pass upon the finished product. Not being satisfied as to the possible outcome of the tile made and cured in this way, he decides to state the case to Mr. A., who has had quite a little experience in making and laying concrete blocks and building cement sidewalks. The engineer states that he has some fifteen and eighteen-inch concrete tile on the ground to be laid, and some of them show signs of crumbling, and do not seem to be solid enough. Some if even pushed over will break under their own weight. Now, will those tile that can be hauled and handled sufficiently to be put into the ground, disintegrate, or will they get harder after being laid? If convenient, I would be pleased to have you visit the field, that you may thoroly understand the situation and give your opinion as to the advisability of using at least a part of the tile. "No use to visit you." "Cement once set or partially set is dead, and will not revive under any condition, so the tile are no good, and should not be used." This is good news to the people against the concrete tile, but leaves the engineer standing between the people and the contractor, both waiting to hear what he will say. He then states the case to a man of quite an extensive experience in the manufacture and sale of concrete tile, but he does not care to put himself on record as to the advisability of using or rejecting the tile in question. The engineer realizes by this time that an opinion favorable to these tile is no good, and that the man taking such a view of the subject will be accused of not telling what he thinks.

Thus it is very necessary that the engineer form an opinion based upon the facts and conditons as they are, and not rely upon the statements of others as to what he shall recommend.

Who is to blame for much of this talk and trouble as to concrete tile? I am of the opinion that the engineer, the people, the manufacturer and the contractor, each have a share in bringing about such conditions.

I recall one instance where the tile specified were to be of clay and as good as a certain factory makes. Now this factory makes and sells good tile; also makes and sells some not so good. In this case, the grade of tile to be used is not mentioned, nor is a sample furnished for a guide. It is just as possible for this to happen in the use of concrete tile as in the use of clay tile. The remedy is for the engineer, in case he writes the specifications, to state clearly the grade of tile to be used.

Another instance comes to mind, when about one hundred and fifty feet of 18-inch tile were laid for an outlet and for some reason, a few of the tile were taken up. Some difficulty was experienced in removing the tile from the bottom of the ditch, and one or two were broken. In a few days, every farmer living in a radius of five miles of that place, knew that the concrete tile were all breaking in the handling.

In another case, a farmer states he has a brother in another section of the state where some county work is being done, and that they were having all kinds of trouble with the concrete tile. I wrote to the auditor of that county, and he said they had experienced no difficulty in using concrete tile.

I believe it is safe to say that there are men here old enough to remember when the cement sidewalk was a very doubtful proposition. The city councils of the various towns did not specify cement for walks especially in the residence parts, because the people believed that concrete would not stand in this climate. This has all been remedied by making a good walk, and so with the concrete tile. Make a good tile, not a 1 to 3 for sample, and some other proportion to market.

A manufacturer may have good tile, be honest and sincere in advertising his products, but he must be careful in stating the proportions used in the making. For instance, some men will condemn the entire output of a factory if they hear a 1 to 4 mixture is used, because they say, "I have tried it and it is no good, and you are simply throwing away your money to invest in concrete tile of that proportion." Another factory advertises porous tile. The general opinion is that the porous part is all right, but some practical men claim they will not stand, and give advice not to recommend them for farm drainage.

Again, a contractor makes too low a bid on some work and asks the manufacturer to furnish him a cheaper tile, in other words, an inferior article. The failures of such tile bring re-

proach upon the concrete tile industry. To educate the public, therefore, it is necessary for every tile manufacturer to see that the finished product is first class in every respect.

DISCUSSION

Pres. Bingham: I am sure the use of cement in drainage is a very important factor in a large part of the state, and any reports and suggestions from a man of as wide observations as Mr. Lilly necessarily has from his connection with drainage projects, will be of value to us. We will have a few minutes of discussion of this paper. Mr. Lilly will be glad to answer any questions, I am sure. Has any one, either a manufacturer of tiles, or who is thinking of it, or has land to drain, any question to ask?

Mr. Lilly: I don't know much about it; I want to learn. If there is any man here, who has used or made machine-made tile, I want to find out how they compare with clay tile in the smaller sizes. How large can we make them with machines, and still do business? Some say they will not stand; I think they they will stand, but that does not solve the problem. I want to hear about machine-made tile, if any one has had any experience.

Pres. B.: On what ground do these people base their claim, that they will not stand?

Mr. Lilly: Well, I don't know that they have any reasons; they criticise, but offer nothing in its place.

Q. I should like to ask the distinction between porous cement tile, and any other tile. I have failed to see any tile, either hand-made or machine-made, that were not porous.

Mr. Lilly: They claim that the tamped tile is solid while it is porous, but not so much so as the other. A slush tile is not tamped at all. If it is properly tamped, you have solid tile.

Pres. B.: They claim that the slush tile takes more water than a tamped tile?

Mr. Lilly: Yes sir, that is the idea.

Q. Was this slush tile made by hand or machinery?

Mr. Lilly: I said that was made by machinery.

Mr. H. C. Shadbolt: I don't think that the slush tile is a porous tile. You will have to show me. I have seen machine-made tile that is certainly porous tile. With certain proportions of cement, you can make machine-made tile that are not porous, and will not take water to any great extent. You can also make them take water very readily. Any one can demonstrate this by taking two tile, one made of a wetter mixture than the other; the first of a consistency that when you take the concrete up in the hands, it will just stand in a ball. Tile made of such

concrete is very porous, and will take lots of water. You wet the same mixture almost to a slush, and still get your tile to stand so that you can take off the jacket, and that tile will not take water. That has been my experience.

Pres. B.: Machine-made tile can be made either so it will draw water readily, or so it won't?

Mr. Shadbolt: According to the amount of dampness you use.

Q. Which are the stronger tile?

Mr. Shadbolt: I don't know; either one is strong enough for any practical purpose.

Q. I would like to ask why in making the specifications for cement tile, after saying that they shall be made of a certain mixture and watered for at least six days, they require them to be kept twenty-four days before laying in the ground. It seems to me that would be the best place to cure them.

A. There doesn't seem to be any reason. These specifications were written some time ago. It looks reasonable that if you could handle them all right, you could lay them in the ditch, but you have to wait a certain number of days before you can haul the tile, and throw them on the wagon, and then out of the wagon. I calculate any tile I can lay in a wagon, and throw out, and put a rod through it, and lay in the ditch, will stand all that would be required of it.

Pres. B.: I think that is true. I mean if they can be handled, they can be used; there is no danger in using them. Concrete is material that hardens well in moisture.

On convening at two o'clock, we will continue the discussion on cement tile and drainage.

Mr. Lilly: In considering this matter between now and then, I wish that every one who can think of an objection will make note, so he won't forget it. I am here to find out, if I can. I don't want some one else to know what I can know if I can find out by asking questions. You will not expose your ignorance if you ask any kind of questions here.

Pres. B.: We will continue the discussion on convening at two o'clock. Mr. M. J. Reinhart has the next number. He has been making tests in regard to standard cement sand, using such material as is most commonly available to us cement users.

STANDARD SAND FOR CEMENT WORK

M. J. Reinhart, Ames, Iowa.

In taking up this subject of sands, although with one principal fundamental object in view, I have worked along two somewhat different lines.

In the first place for a matter of comparison largely, or in

other words, to show what the very best sand should be like, I have attempted to form, by mechanically putting together the different graded particles, what might be regarded as a standard sand for cement users.

Secondly, I have attempted to determine and show how ordinary sands could be improved by screening or by the addition of the proper material to give the minimum amount of voids, and thus afford the maximum results at the least possible cost.

Before going farther I wish to state, however, that the time I have had in which to make this investigation has been very limited and that the numerous experiments that might well have been made in working up such a subject had to be for the most part omitted; and while my mechanical mixtures have greatly decreased the amount of voids and materially increased the strength of mortars made therefrom, they may or may not be the best possible mixtures that can be made from such materials.

The sand I have used in this experiment is a bank sand taken from the college pit and is of exceptionally good quality, con-

FIGURE 1

taining but thirty per cent voids, while the ordinary run of Iowa sands contains from thirty to forty per cent voids. It is a comparatively coarse sand, and largely free from earthy materials.

To begin with all that failed to pass a No. 2 sieve was rejected. This was a very small per cent of the material, about three per cent, and it was the grades from this size down that were used in making the mixtures.

The screens used in separating the sand into the various sizes were as follows: The No. 2, or two meshes per lineal inch; the No. 4, or four meshes per lineal inch; the No. 8, No. 16, No. 30 and the No. 50 screens. With the above screens a given amount of material was divided into the six following graded sizes: that which passed the No. 2 and was retained on the No. 4; passed the No. 4 and was retained on the No. 8; passed No. 8 and was retained on the No. 16; passed No. 16 and was retained on No. 30; passed No. 30 and retained on No. 50; and finally that which passed the No. 50 sieve. In each case the per cent of the whole was determined by weight and the voids in each separate part determined. The above Fig. 1 shows the results of this separation; the height of sand in each short tube compared to the height in the long tube shows the proportional part by weight of that grade compared to the whole; the per cent of voids and the grade of material is marked over each tube.

In determining the voids the following method was used: a cylindrical vessel holding about a pint was carefully filled with sand up to a horizontal line around the jar, and settled somewhat by shaking and tapping the sides of the vessel, but not tamped, and then weighed. The vessel was then emptied and a certain amount of water poured in, approximately equal in volume to the voids in the sand. The sand was again carefully put back into the jar and water enough removed or added to cause it to stand just to the level of the line around the glass. The difference in weight between the vessel filled with sand and water, and the weight of the vessel and sand alone is the weight of the water required to fill the voids of the sand. Next the weight of the water required to fill the vessel up to the horizontal line was determined and by the following expression the per cent of voids was calculated:

$$\frac{\text{Weight of water required to fill the voids}}{\text{Total weight of water}} \times 100\% = \%\ \text{voids}.$$

In all cases two determinations were made and the average taken.

Next, a properly graded sand was attemped, by putting the right amount of each grade of sand into the mixture. The weight of a certain amount of the coarsest material was found,

and to it was added just enough of the next size to fill the voids. This gave a material made up of particles or pebbles which passed the half-inch mesh screen and were retained on the eighth-inch sieve. The voids of the large size was 44.2 per cent; of the small size 42.4 per cent, and of the mixture 38.0 per cent. To the mixture was then added enough of the third size to fill the voids, and so on down to the finest material, which passed the No. 50 sieve. Table I shows the weight and voids of each material and mixture.

TABLE I.

PROPERLY GRADED SAND.

Kind			Quantity in Mixture		
Passed	Retained on	Percentage Voids	Separate	Combined	Per cent. of Total
No. 2	No. 4	44.2	3 lbs. 2. oz.		22.9
No. 4	No. 8	42.4	1 lb. 6.1 oz.		10.2
No. 2	No. 8	38.0		4 lbs. 8.1 oz.	
No. 8	No. 16	43.4	1 lb. 11.4 oz.		12.6
No. 2	No. 16	33.5		6 lbs. 3.5 oz.	
No. 16	No. 30	38.7	2 lbs. 1.4 oz.		15.5
No. 2	No. 30	28.9		8 lbs. 5 oz.	
No. 30	No. 50	38.1	2 lbs. 6.4 oz.		17.6
No. 2	No. 50	26.9		10 lbs. 11.4 oz.	
No. 50		35.5	2 lbs. 14.1 oz.		21.2
No. 2		24.4		13 lbs. 9.5 oz.	

It will be observed that the final mixture contained 24.4 per cent voids, the original sand 30 per cent, a reduction in voids of nearly 19 per cent. This was the second mixture tried, the other by adding an excess of fine material each time gave a slightly larger per cent of voids. Fig. 1 shows the comparative amounts of the different grades of sand used. Here the makeup of the natural sand can be readily compared to that of the properly graded sand.

Next a mixture that would be practicable for improving sand was tried, one which by one screening of the sand the voids could be materially reduced.

It is a generally known fact that if to ordinary sand fine pebbles as an aggregate be added a stronger mortar can be made from the sand, if mixed in a given proportion. So it was decided to add to the ordinary sand a certain amount of aggregate which passed a No. 2 sieve and was retained on a No. 16 sieve. To determine the correct proportion to add, a determination was made to find the per cent of aggregate larger than that which passed a No. 16 sieve as well as the voids of the aggregate.

It was found that 34 per cent stopped on the No. 16 screen and that this material had 34.2 per cent voids. Starting thus with a given amount of this coarse material 16 lbs. , the proper amount of natural sand to add in order to just fill the voids was calculated thus:

Let x=the amount of coarse material or aggregate in the sand.

Let y=the total weight of sand.

Then,

Equation (1), $(16-x) \times \frac{34}{100} = y-x$, and

Equation (2), $x = \frac{34.2}{100} y$

Solving y=10 pounds.

In other words, to 10 lbs. of sand was added 16 lbs. of the coarser material, and this mixture contained just 25 per cent voids, a reduction in voids of nearly 17 per cent.

By the same method of determination the proper amount of aggregate to add to any sand or gravel might be determined.

In order to show the comparative strengths of mortars made from the three sands, the natural, the properly graded mixture, and the mixture improved by one screening only, tests have been made, both for tension and compression. The specimens tested were ordinary briquettes for tensile strength and six inch cubes for compressive strength. Table II shows the comparative strengths of the materials.

The results show the value of having the graded materials in a mixture of sand, and the fine material in the proper proportion to fill the voids in the larger aggregate. This was not a concrete but a mortar of about the consistency for cement blocks, tile, posts, etc. In the natural sand there was a deficiency of both the coarse and fine material, while in the other mechanical mixtures this fault had been largely overcome. In the former, mixed in a proportion of 1 to 4 the cement was insufficient to fill the voids, while in the latter case it was just sufficient, and hence the results.

I realize that it is impossible to find in nature a sand that will compare to a mechanical mixture prepared in the laboratory, and that in the same pit or location in a stream from which sand is taken there might be considerable variation. I nevertheless consider that it would be advantageous to the cement user to know how the sand he is using does compare with the properly graded sand. Again, it often happens that any one of several different sands may be used with little or no difference in cost. For these reasons, and to serve somewhat as a guide in selecting

the sands to use, I have prepared two hundred samples of mechanically proportioned or standard sand for free distribution to the members of this convention.

On examination of these samples you will find that there is about the right amount of fine material to fill the voids in the coarser, and that is what we want. In few sands is there an excess of coarse material, in most an excess of the fine, but wherever possible to find a sand which compares favorably with this one it is quite certain, that for cement work, you have a sand that is not far wrong.

COMPARATIVE TESTS.

TENSILE STRENGTH				CRUSHING STRENGTH					
Briquette No.	Proportions	Age When Broken	Tensile Strength Pounds per □"	Specimen No.	Proportions	Size.	Age When Crushed	Total Load	Crushing Strength Pounds per □"
		Natural Sand							
2	1—3	7 Days	365	2	1-4	6"×6"×6"	7 Days	68000	1885
2	1—3	7 "	360						
2	1—3	7 "	355						
2	1—3	3 Mo.		2	1-4	6"×6"×6	3 Mo.		
2	1—3	3 "							
2	1—3	3 "							
2	1—3	1 Yr.		2	1-4	6"×6"×6"	1 Yr.		
2	1—3	1 "							
2	1—3	1 "							
2	1—3	1 "							
		Sand Improved by One Screening							
1	1—3	7 Days	365	1	1-4	6"×6"×6"	7 Days	94000	2611
1	1—3	7 "	410						
1	1—3	7 "	400						
1	1—3	3 Mo		1	1-4	6"×6"×6	3 Mo.		
1	1—3	3 "							
1	1—3	3 "							
1	1—3	1 Yr		1	1-4	6"×6"×6"	1 Yr.		
1	1—3	1 "							
1	1—3	1 "							
1	1—3	1 "							
		Properly Proportioned Sand							
3	1—3	7 Days	410	3	1-4	6"×6"×6"	7 Days	77000	2139
3	1—3	7 "	405						
3	1—3	7 "	395						
3	1—3	3 Mo		3	1-4	6"×6"×6"	3 Mo.		
3	1—3	3 "							
3	1—3	3 "							
3	1—3	1 Yr		3	1-4	6"×6"×6"	1 Yr.		
3	1—3	1 "							
3	1—3	1 "							
3	1—3	1 "							

Table II

[illegible] the matter of [illegible] sand [illegible] this is [illegible] how [illegible] cement products [illegible] the sand he is using [illegible] Engineering [illegible] and [illegible]

DISCUSSION

[illegible] Bergman: Before starting the discussion of this paper I [illegible] say that any who have brought samples of [illegible] may leave them here in the [illegible] Mr. Rennart has very kindly offered to do this and [illegible] your address with him, he will report to you. I [illegible] as [illegible] make the test after the convention [illegible] Secretary Williams has been very fortunate [illegible] Senator Dolliver. He [illegible] in the College Chapel at 11:30. We [illegible] at 11:15 so as to be on time, as there will doubtless be [illegible] there. We can now continue the discussion.

Mr. [illegible]: I would like to ask what the percent of moisture [illegible] of the determination of the voids.

Mr. Rennart: I [illegible] say in answer that, in making determinations of voids, we should have no moisture in the material; it should be dry.

Q. What effect has clay or soil in the sand on the product?

Mr. M. H. [illegible]: Fifty per cent of clay with sand will give good [illegible] work.

Mr. R[illegible]: Early in the year 1904, I took up a certain line of tests for my thesis at this institution. We started in to make comparative tests by mixing fine or clay materials with the sand. The line of experiments that was carried on first tested natural or standard sand without any dirt whatever in it. Then by taking two per cent clay, and four per cent, six per cent, etc., up to as high as twenty four or twenty-six per cent. On making the strength tests, it was found that the sand with the dirt in it

made sronger mortar than the clean sand. Even as much as twenty per cent of clay in the sand did not affect its strength qualities. They were even greater. But altho this showed in the tests, I did not conclude that it was a good thing to use dirty sand. The briquets were set away in the laboratory down stairs, and left there in water all that summer. During that time, the trays in which they were kept began to leak, and dried out. There was just a little water left at the bottoms when I returned in the fall, and all those that had clay and loam in them had begun to peel off and crack, while those made with the natural sand showed no signs of deterioration whatever. This showed that while clay or loam gave strength, they did not give lasting qualities.

Mr. Wm. Seafert: What was the strength of these briquets?

Mr. Reinhart: Well, of course I didn't go on with the tests; there were not enough left.

Mr. Ireland: In regard to the use of hydrated lime, has any one here tested that?

Pres. B.: I have no doubt a number have used hydrated lime. Would be glad to have reports on that. Mr. Ireland wishes to know whether the addition of hydrated lime makes a better product at an increased cost such as will be warranted, or whether it adds any to the cost. Is it a practical thing to use?

Mr. F. Perkins: Hydrated lime is used with cement in our neighborhood in order to keep the cement from setting so quickly that the mason is not able to use it in brick work and work of that class. That is the only way I know of its being used. As to whether it increases the strength of the cement, I don't know.

Pres. B.: Its use in making blocks was Mr. Ireland's particular question.

Mr. Ireland: My object in trying it was to see if I could get a smoother finish on the work, more like polished work.

Mr. Seafert: Where they use lime in mortar, it is prepared six months ahead. The specifications call for lime to be slacked six months before using. If they make a paste and store it for six months, it gives a finer effect.

Pres. B.: Has any one anything further on the question of sand composition, so as to produce better results. Maximum of density gives maximum strength. Has any one had any experience in regard to practical means of increasing the value of the sand or gravel they are using.

Q. Our bank sand or river sand is generally considered the best. I have used both and the result has been good.

Pres. B.: What have your results been?

A. We have had the best results with bank sand, and without the use of screens on either of the sands.

Pres. B.: Just as they come?

A. Yes sir.

Pres. B.: Was your river sand fine? Would it grade up the same in proportion, in fineness, as your bank gravel?

A. I think it would, but we had not as good results with it as we had with the bank sand.

Pres. B.: What has been the experience of others? Which gave the best result? My experience has been that bank sand in our vicinity is the better of the two, but I would not say that all bank sand is. I select the best sand I can find, and I get better results than from the river sand available in my locality. In other places, sand taken from the stream might be better.

Q. Better results in what direction?

Pres. B.: Stronger.

Mr. Kenney: I have had some little experience with bank sand, and find that it makes good strong work, but I have not been able to find any bank sand as clean as river sand. I get my material out of the Des Moines river. I could get bank material a little cheaper, but I do not consider it quite so lasting. River sand is absolutely clear of impurities.

Q. Have you tested your bank sand?

Mr. Kenney: I have not.

Pres. B.: The time has come for adjournment. We will meet here this afternoon at 2. Meeting adjourned.

THIRD SESSION

Thursday Afternoon, 2 o'clock

Address by Senator J. P. Dolliver.

Gentlemen of the Convention: It seems a little odd that I should be drawn into a convention interested in the products of cement. But to tell you the honest truth, the first business that I ever did in this world was to act the part of off-bearer in a brick yard down in the mountains of West Virginia, in order to accumulate funds enough to get out of that section of the country. At that time, this department of industrial art was a little primitive in its development. I have an idea that no department of active industry has seen such progress as the department of clay and rock manufactures in the last thirty years, and it is time the business was showing signs of life, because it is the most ancient, if not the most honorable occupa-

tion, of mankind. The only trace we have of the earliest civilization is the discovery of idols and building materials of clay and of rock. The oldest known literature in the world was written upon a column of rock. In making excavations in Babylon, Dr. Harper of the University of Chicago, discovered some of these letters dating back 2500 years before Christ.

So you see you are in the oldest business there is, and one of the most profitable, altho you do not seem to appreciate that fact. Having a little piece of land up in Webster county that contains in a single forty acre section, a deposit of cement rock and cement clay and gypsum, and coal, for there is no end to the resources of this state in which we live, I wanted to put in a little cement plant for the purpose of manufacturing the article, with a view of fitting out the farm upon which these materials are located as it ought to be. I asked a man here today, and he told me it could not be done as it should be for less than $600,000. The minute he said that, I recalled a session of the Brick and Tile people at Des Moines, where a learned brother read an essay, saying that $50,000 was the least possible amount for which a brick plant could be equipped. In the five minute discussion, another brother got up, and said he had listened with great attention to the learned essay in which it was proven that a brick plant could not be equipped for less than $50,000, and all the while the brother was speaking, he said it had been running through his head, "If I had $50,000, what in H—— would I want with a brick yard."

Now I would not have come over here if I had not got it into my head that you fellows are on track of the most fruitful step that has yet been taken in the progress of the building up of communities. We are bothered a good deal now about trusts and combines, and I suppose that I have stayed awake nights worrying about what was going to happen to us about as much as anybody, at least as much as anybody ought to. But here lately, I have been feeling more comfortable about it, and strange enough, I got my comfort and drop of satisfaction out of a hereditary theology which came from my home. My father was a preacher, though you might find it difficult to credit that, and he always claimed that God made this world, and naturally it was his opinion that the Lord had made a fairly good world and had surrounded it with forces and influences which go pretty far in the direction of justice and equity and fair dealing toward men. I quit worrying about nearly everything that is happening in this world, because it is literally impossible for anybody to organize a scheme to rob the whole community until the laws which God has made are repealed, and congress has not yet undertaken that job.

I have studied the laws of consumption with a view of finding out, if possible, what chance there is to practice the arts of extortion and injustice in a market place like ours, and I have found concealed in the debris one law of which you are the executors. It is called the law of alternative consumption, the law by which the market place turns naturally from a thing that is too high in value to another that answers practically the same purpose; so that nearly everything, while it may be a necessity, has natural competition that is not set on foot, either by acts of congress or joint resolutions of the state legislatures.

Let me illustrate what I mean. One of the most perfect monopolies in the United States is the manufacture of tin plate; but there is no use for tin plate that does not have a hundred competitors. If one man made all that is made in this world, he would still be very far from having a monopoly, because for every article manufactured of tin, there are some half dozen articles equally good and some of them infinitely better. Take the tin cup—how many competitors does the tin cup have? The tea cup, the glass goblet, cups in a dozen forms from the iron cup on the street fountain to the cup of gold or silver which is presented to us in our infancy.

Let me give you another illustration. I kind of think that the Lord intended us to build our houses out of wood; he certainly did in those sections of the country where you had to cut down trees before you could get a place to build a house. In the early days, it was perfectly easy to build a house out of wood, but we have been guilty in the United States of the most terrific extravagance of our resources. We have allowed men who live but seventy-five years to cut down trees that it takes a thousand years to produce, and from all over the United States comes the cry that our trees are going. I think that the government of the various states, and of the United States, would perform an act of far-sighted wisdom if they would make it almost as much of a crime to cut down a tree as it is to kill a man, because there are a lot of fellows we could do without, and there is no possible remedy for the destruction of life and civilization incident to the loss of the forests of our country.

Now, the scarcity of timber, and of other things too numerous to mention, has put the prices of ordinary boards so high that nobody can buy them, and anybody that is contemplating building a house, or a hog pen, or a barn, or anything else, is up against the proposition that the material is almost out of the reach of the average citizen. But the Lord has not left us in that situation. We still have rocks, bricks, and a half dozen other things, and now you fellows come along with the most

perfect of building materials, and the most enduring, in the history of the world.

I am building a house,—that is to say, I am *going* to build a house. We have been building it, my wife and I, for the last five years, and we haven't got very much beyond the plans and specifications; you needn't laugh, because you can get more fun out of plans and specifications sometimes than out of the house. The very minute we saw the price of wood going up, we began to investigate the question of building a house out of brick, and we have got it figured now so we know we can build a house out of pressed brick within two hundred dollars as cheap as wood. We intended to build out of brick just as soon as we could get the money, but we postponed it, because I tell my wife that within five years you people will have wrought miracles in the supply of building materials in the United States, of which nobody even dreams today. And that is the reason I came over here. I wanted to find some congenial society.

Why, I have seen five miles of telegraph poles on the Pennsylvania Railroad, just east of Chicago, made out of cement, and far out upon the plains of western Nebraska, only last fall I found a place manufacturing as pretty a brick as you ever saw in your life, and they color it from a bright red to the beautiful pink of strawberry ice cream.

Now, how are the lumber trusts going to rob us on building material in the future? But you say, these cement fellows are liable to form a combine and sift this blue mud out to us on terms not agreeable to the economical conscience of the country. Well, I don't know whether they are or not. I know there is a tendency to take as big a rake-off on the commodity as can be done, but I can't believe that the price of cement can be permanently kept up in the United States.

There is another law which God made and has not repealed, which I call the law of maximum consumption; that law by virtue of which a great business moves and depends upon its magnitude and not on robbing a few people here and there. I have seen this illustrated in the case of such monopolies as the American Sugar Company. They have no more control over the price of sugar than you have; if they raised the price at the wrong time, it would mean bankruptcy. While this thing has become a necessity, it is not necessary for us to buy everything just now. I remember myself when the price of sugar was thirty or forty cents a pound, and the per capita consumption of sugar in the United States was on an average three pounds. Today, the price of sugar has gone below five cents at retail, and the consumption of it is nearly seventy-five pounds for the average man, woman and child. I recall in the old Virginia homestead, we

bought it by the barrel, just once a year, and it was a sort of a celebration when we got the next year's sugar. We carried it carefully into the house, and put it in the closet under the stairway. My mother locked he door, and kept it locked always, although one of the tragedies of my childhood was when the door happened to be left open, and I entered the sacred precincts, and was unable to get my head out of the barrel before the exercises began.

So it is with these people who are putting in these great and costly plants in Iowa, Kansas and Missouri. I have stopped off wherever I can hear of one of these plants being built. I have gone to see it, because I have got it into my head that this proposition that you are interested in is the biggest proposition in the industrial work. I have been to Independence and all those natural gas cities of Kansas, and in Missouri and Illinois and Michigan, wherever I can hear of one of these plants, because they represent an infinite addition to the resources of the United States.

If they do undertake to monopolize the manufacture of this product, they will be up against the real thing, because the Lord never made a world where a few people could gather up resources such as these.

When any one has a particularly good thing, there are always a lot of amiable looking people standing near, watching the process, ready to skim the cream off, and by and by some one else thinks it is a good thing for him, and that law runs through the whole world. I have frequently been in the barn yard and watched the performances of the domestic fowls. I have seen an old hen get hold of some article, big and juicy, and she never eats it; she picks it up and lays it down, then starts on the run with it, lays it down again; then runs around the barn a couple of times, and by and by she lays it down in sheer fatigue, having learned the everlasting lesson that whoever has a good thing in this world, has to give it up or divide.

I have studied the market place and have found that our law of competition, which God made for the protection of his children in this world, has not yet been repealed, and it cannot be repealed while such a body of men as this are engaged in manufacturing the products for which cement is necessary. If you have found a fixed purpose in any part of the United States to monopolize this industry, you turn this convention, you men who are manufacturing these articles, into a great manufacturing enterprise. Uncle Sam has given some good examples of this. We were building a dam in Phoenix, Arizona, and we asked bids on cement by the million tons. These boys who were manufacturing this peculiar blue stuff, they said that Uncle Sam

was an easy proposition, and made a statement of their figures that bewildered your Uncle Samuel. He wrote to the department of the Geological Survey where pretty soon they found that your Uncle Sam was being touched for about two million dollars. Being sensitive at his time of life, he stopped building the dam long enough to build a plant for making Portland cement, and is now turning out his own cement, for his own dam, and paying for it with his own money.

Now it lies with you men to defeat all kinds of monopoly that do away with the benefits that have come from this great step in the development of the world's resources. Let men know what this great discovery means for the world, and you will contribute to the welfare of your fellowmen infinite resources of which you are the stewards, throughout the years to come. (Applause.)

Pres. B.: The first number on the printed program is the

Demonstration of Cement Tests

by Professor F. C. French.

Mr. French: Mr. Chairman, Gentlemen of the Convention: When the secretary asked me to take this up it was understood that I should go through the performance of some actual tests that are made in testing cement. I will take it up by first reading to you the specifications adopted by the American Society for the Proper Testing of Materials and endorsed and recommended by the American Society of Civil Engineers, and will then show you the methods they recommend for cement tests.

The tests recommended by the American Society for Testing Materials are as follows:

SPECIFIC GRAVITY.

The apparatus used is Le Chatelier's apparatus, and consists of a flask of 120 cu. cm. capacity, the neck of which is 20 cm. long, and in the middle of this neck is a bulb containing 20 cu. cm. The neck has a diameter of nine millimeters, and is graduated into tenths of a cubic centimeter. The test is performed as follows:

Benzine or kerosene, free from water is introduced into the flask up to the bottom of the bulb; 64 grams of cement previously dried in a temperature of 212 degrees F. and cooled to the temperature of the liquid, is introduced into the flask through a glass funnel, until the liquid rises to the top of the bulb. The cement remaining is then weighed, and the difference between this weight and the 64 grams divided by the displaced volume, will give the specific gravity.

FINENESS TEST.

Sieves used in this test are 20 cm. in diameter, and 6 cm. high, provided with a pan 5 cm. deep, and a cover. The No. 200 sieve has 188 to 200 meshes to the linear inch, and the No. 100 sieve has 96 to 100 meshes per linear inch. These sieves should be made from brass wire, woven, the wires being .0024 inches in diameter for the No. 200, and .0045 inches for the No. 100. Fifty grams of the cement previously dried in a temperature of 212 degrees Fahrenheit is used, and the method is as follows: Holding the sieve in your hand, it is swung back and forth at the rate of about 200 strokes per min., at the same time gently striking the sieve with the palm of the other hand. The operation is continued until not more than one-tenth of one per cent passes through, after one minute of continued sieving. The work can be expedited by placing in the sieve a quantity of large shot.

. TEST FOR NORMAL CONSISTENCY.

This test is made by means of the Vicat needle apparatus which consists of a rod 1 cm. in diameter, weighing 200 grams, and moving in a frame containing a scale graduated to millimeters. The cement for this test is placed in a conical hard rubber ring, 7 cm. in diameter at the base, and 4 cm. high, resting on a glass plate. This ring is filled with the cement, and is mixed with the proper percentage of water, when the needle penetrates to a point 10 millimeters below the top of the ring. Trial percentages of water are used until the proper one is found.

TIME OF SETTING.

This test is made with the Vicat needle, the same as above, except that the needle has a diameter of 1 millimeter. A rubber ring is filled as before and setting is said to have *commenced* when the needle penetrates to a point five millimeters above the upper surface of the glass, and setting is said to have *finished* when the needle does not visibly sink into the mass of cement.

MIXING.

Material is weighed and placed on the mixing table, having a top of some non-absorbing substance such as glass or slate, and a crater is formed in the center, into which the proper percentage of water is poured at once. The cement is then sifted into the water until the water is all absorbed, which should require about one minute. The mass is then mixed with the hands for a period of one and one-half minutes, similar to the process of kneading dough.

MOLDING.

Molds of the form recommended by the American Society of Civil Engineers are filled at once, and he cement is pressed in firmly with the fingers. The top is then smoothed off with a trowel, held in such a manner as to exert a pressure on the cement in the molds. The mold is then turned over, and the process repeated. A check on the uniformity of molding is afforded by weighing the briquets just prior to immersing in water. Briquets which vary more than three per cent in weight should be rejected.

STORAGE OF TEST PIECES.

A moist box is preferred which consists of a box made of glass or slate or a wooden box lined with zinc or tin, and this lining covered with felt which is kept wet with water. Where a moist box is not available, the test pieces may be covered with a damp cloth, supported just above the pieces on a wire screen, and both ends of the cloth resting in a pan of water, so that the cloth will not dry out.

TENSILE STRENGTH.

This test may be made on any standard machine which gives the breaking strength in pounds per square inch. The machine used in the College is an old style shot machine. Care should be taken in centering the briquets in the clips, and the load should be applied uniformly at the rate of about 600 lbs. per minute. The average of the briquets for each sample of cement should be taken excluding any results which are manifestly unfair.

CONSTANCY OF VOLUME.

This test is made by making three pats each 7½ cm. in diameter, by 1¼ cm. thick at the center, and tapering to a thin edge. These pats are formed on glass plates, and kept in moist air for 24 hours. One pat is then immersed in water at 70 degrees F. for 28 days. A similar pat is maintained in air at ordinary temperature, and both are observed at intervals. The third pat is exposed in any convenient way in an atmosphere of steam, above boiling water, in a loosely closed vessel for a period of five hours. To pass the tests satisfactorily the pats should remain firm and hard, and show no signs of checking, cracking, or distortion. Should the pat leave the glass, distortion may be detected with a straight edge, applied to the surface which was in contact with the glass. A failure to pass the accelerated test would not be cause for rejecting the cement, but such cement should be retained until the 28 day tests could be completed.

Pres. B.: We will now go back to the question of cement as used in drainage, and will re-open the discussion that was interrupted at the noon hour. We will have a talk on this subject by Mr. H. C. Shadbolt.

Mr. Shadbolt: Mr. President, Gentlemen.—It is not my forte, speaking before the public, and I cannot see why this committee has put me on to talk on the manufacture of cement tile. I assure you that what I do not know about cement tile would make a big book. I have been associated something like six or seven months with the manufacture of cement tile. Of course I made experiments along certain lines and drew my own conclusions, and I can assure you they are not of a scientific nature.

The small tile I have made and sold to the public were a 1 to 4 mixture. By small tile I mean tile that are from 4 to 12 inches in diameter, inclusive. All the tile from 13 to 24 inches were of 1 to 3 mixture.

I made up a lot of samples on the 28th day of December, which I shipped as baggage when I came down here, but they were not handled as carefully as they might have been, and being young tile there were quite a number of them broken. I also shipped down quite a few that I had taken from my stock tile to be tested to find out what I was doing and to know what proportions I would have to use to make good tile from the sand I was using.

The tile that I have taken for the experiments were made from 1 to 3, 1 to 4, 1 to 5, 1 to 6, and 1 to 7 mixtures. They were made, as I say on the 28th day of December. The mixtures were proportioned by the use of a box holding exactly one cubic foot, and neither cement nor sand were tamped into the box. As I understand it, a cubic foot of cement should weigh 95 pounds, but by pouring it into the box you get only 85 pounds. After getting the mixture, it was moistened just enough so that when taken in the hand and compressed it would stand without crumbling. It was then manufactured into tile, placed on the shelves and allowed to stand for eighteen hours before it would stand watering. After this the tile were given all the water they would absorb three times each day for five days. They were then allowed to dry.

None of these tile were what would be called weak mixtures for tile, except the 1 to 7 mixture.

The engineering department of the college has been kind enough to test some of these tile for their crushing strength, and has given me the results of the tests of the different classes of tile.

The tile that were broken are here in the room, and show

how they broke under the pressure exerted. The tile was laid in a box and imbedded in sand, with a block put on top, and the tests of the different tile showed the following results:

4-inch tile, 1 to 3 mixture, stood a crushing pressure of 715 lbs.
4-inch tile, 1 to 4 mixture, stood a crushing pressure of 755 lbs.
4-inch tile, 1 to 5 mixture, stood a crushing pressure of 370 lbs.
4-inch tile, 1 to 6 mixture, stood a crushing pressure of 390 lbs.
5-inch tile, 1 to 6 mixture, stood a crushing pressure of 340 lbs.
4-inch tile, 1 to 7, which I did not consider a proper mixture, broke at 285 lbs.
5-inch tile, 1 to 7, broke at 275 lbs.
6-inch tile, 1 to 7, broke at 495 lbs.

The test of the stock tile, which were made during November, shows the following results.

4-inch tile, 1 to 4, stood crushing strain of 795 lbs.
5-inch tile, 1 to 4, stood crushing strain of 1035 lbs.
6-inch tile, 1 to 4, stood crushing strain of 795 lbs.

The 4-inch which you see before you stood a strain of 980 pounds and retained its shape, showing but a small crack. These tile were all treated as explained before, and this I find, after experimenting, is the best method of treatment. I had in this lot one 5-inch tile which was tested and stood a crushing strain of 685 pounds. This tile was allowed to stand twelve hours, watered four times, placed under the eaves where it alternately got the drip and frost for seven days, after which it was taken in and thawed out and dried. You will see that this tile stood nearly the same crushing strain as the tile of the same mixture that was tested just before it. My reason for doing this was to ascertain whether or not freezing would affect the tile after a certain amount of crystallization had taken place, and I am of the opinion that freezing does not hurt tile after crystallization has bone on for from twenty-four to thirty-six hours.

In breaking these tile, in every instance they broke into four pieces lengthwise of the tile.

Taking into consideration the fact that these tile were all manufactured in the winter time when crystallization is slow to start and given little or no chance to cure properly, I think they stood exceptionally good tests for strength. It is conclusive in my mind, from the tests shown, that tile made in the winter time should be handled with great care and retained in the house a longer period of time, given more water and allowed more time for curing. While I have not been an advocate of low

grade mixtures in making tile, we must not overlook the fact that the lower grade mixtures are better tile for drainage purposes, providing they can be made strong enough to do the work properly. The 1 to 3 tile absorbs very little moisture, while a 1 to 4 takes moisture very readily, and you can run a stream of water directly through a tile made of 1 to 5 mixture. I think a tile of 1 to 5 mixture, with the proper sand would be the right mixture to use for all small tile, that is, from 4 to 12 inches. In my mind, the mixture to be used for larger tile should not be less than 1 to 4.

I have had but little experience along this line, but I think by the first of May I will have had a great deal, as I have about 7000 dollars' worth of them strung out along a ditch. The tile were to be laid last fall, but the contractor for the open work did not get the ditch completed in time to put in this work. These tile are standing in water all the way from one and one-half to two feet deep, and, if you consider this a test of cement, it will probably be made on the ditch this winter, and I will find it out in the spring.

As I have said before, my experience in the manufacture of cement tile is very limited. I am but a beginner; I came here to learn what I could in regard to the manufacture of cement tile. I am perfectly willing to state what I know and if my experience will help anyone I assure you I am glad to give it. It places me in rather an embarrassing position, not being a good talker before an audience. If there are any questions you wish to ask that I can answer, I will be pleased to do so. In the meantime, the tile are here and you can see the sand in the mixture used and satisfy yourselves as to whether the tile are good for anything or not.

Q. What are the largest size tile you make from 1 to 5 mixture?

A. I have made no tile over 6 inches of a 1 to 5 mixture. The 10 and 12 I make 1 to 3.

Q. Was the pressure put on the side of the tile?

A. Directly on top. They were placed in a square box, sand was packed at bottom, sides and top of the tile, and the pressure applied from the top.

Q. Were your figures given to the square inch?

A. No. Only to show breaking pressure.

Q. That is the actual pressure that was put on the tile in the box, without regard to the surface over which it was distributed?

A. The pressure was distributed over the whole surface.

Q. Can they be made cheap enough to compete with the clay tile?

A. That all depends on the size you make and the mixture you use.

Q. Well, basing it on a 1 to 5 mixture?

A. With a 1 to 5 mixture, you cannot compete in cost, but you can compete at nearly every point in the state as far as the selling price is concerned.

Q. How does the test compare with the clay tile test?

A. I never saw a test of clay tile myself, and so do not know.

A. About three times as strong as clay.

Q. Do you make large cement tile?

A. I do.

Q. How large before you reinforce them.

A. Reinforce after 24 inches.

Q. What method?

A. A hoop wire is used for reinforcement a great deal; it seems to be the best thing we have struck so far.

Q. How would clay tile of 24 inches compare with cement

A. The price we have been able to secure for tile of that
tile, as far as price is concerned.
kind is about 30 per cent in excess of the cost of cement.

Q. Is this for ordinary straight tile?

A. Yes.

Q. How long do you leave the molds on large tile?

A. Take them off at once.

Q. What is sand worth a yard?

A. 75 cents with us.

Q. For the purpose of comparing cement with clay, say 5-inch tile is worth two cents; what would the cement tile be worth approximately?

A. Of a 1 to 4 mixture, approximately the same.

Q. What is the cost of making?

A. Very close to the selling price. Of course these tile have different prices in different localities. There are no two men that I have talked with that produce their tile at the same cost.

Q. Figuring on the cost of tile there, are they made by hand or machine?

A. By machine.

Q. What difference is there?

A. A vast difference.

Q. I mean in the price.

A. The nearest conclusion I can give you on that is on the manufacture of twelve inch tile. Three men, for instance, will make eighty 12-inch tile by hand.

Q. In 10 hours?

A. Yes. That will be about the average you will get with hand tamped molds, while you can make 2000 12-inch by machine.

Q. What kind of power do you use?

A. Gasoline.

Q. How many horse power?

A. Ten.

Q. Do you make large tile by machinery?

A. As high as 12-inch.

Q. Have you tried steam curing your tile?

A. No.

Q. Do you know of any cases where they have collapsed in the ditch?

A. I do not, but while we are on the subject, will say of the tile that stood 685 pounds pressure, that in breaking they broke right thru the pebbles and in all of these tests which you see here, you will find the small pebbles were broken.

Q. What do you figure the thickness and the cost of 30-inch cement tile, and how thick you do make them?

A. Well, what mixture do you want?

Q. I presume 1 to 3, or 4.

A. Well, 30-inch tile, 1 to 3 mixture, sells for about $1.00 per foot.

Q. How thick is the body of the tile?

A. Two and one-half inches.

Q. What is the weight of the cement tile?

A. They weight as follows: 24-in. tile, 150 lbs.; 22-in., 135 lbs.; 20-in., 120 lbs.; 18-in. tile, 100 lbs.; 16-in. tile, 83 lbs.; 15-in. tile, 60 lbs.; 14-in., 50 lbs.; 12-in. tile, 38 lbs.; 10-in. tile, 28 lbs.; 9-in. tile, 24 lbs.; 8-in., 18½ lbs.; 7-in. tile, 16 lbs.; 6-in. tile, 13 lbs.; 5-in. tile, 9 lbs., and 4-in. tile, 6½ lbs.

Q. How thick is your 24-inch tile?

A. Two inches thick.

Q. What would be the approximate value of the 24-inch tile per foot?

A. It varies some. They generally intend to get 60 to 65 cents.

Q. When you speak of reinforcing with 4 to 6 wires, is that for two foot long or one foot?

A. Two feet long.

Q. What number wire do you use?

A. No. 9.

Q. Smooth or twisted wire?

A. Smooth.

Q. Galvanized or black?

A. Galvanized.

Q. Barbed wire?

A. No.

Q. What did you say was the retail price on 24-inch tile?

A. Retail from 55 cents to 65 cents per foot.

Mr. Shadbolt: I have.

Q. What do you figure they cost?

Mr. S.: From ten to fifteen per cent more, owing to your workmen.

Q. Do you reinforce that work?

Mr. S.: I do not. In making 24-inch tile your three men ought to turn out sixty tile per day, ten hours' work. With the sewer pipe, you will only get fifty tile per day.

Q. How large sewer pipe?

Mr. S.: I have made 24-inch.

Q. I would like to ask if any gentleman present has had any experience in curing tile or other cement product by steam.

R. We are making small tile, no large ones, but I expect we will have to come to it. We are within about eighty feet of the electric light plant in our town, and are using some of their exhaust steam. We started up about the first of November. The steaming is all right. It hastens the setting, because it is warm. I do not know that steam is any stronger than water, nor do I know that the tile are finally any stronger, but we can take our tile out sooner. We have been told that they can be cured in twelve hours, and also told twenty-four hours, but I don't believe it is possible to do that. But we *have* taken them out when they are two and one-half days old, or three, and had no trouble by crushing. We shipped on Wednesday a car of tile that were made on Thursday the week before, and found one hundred and thirty broken in that car. These ought not to have been shipped; we knew better, but the fellow wanted them. He put them in the ground and about five weeks later came to pay for the tile. We asked him how the new tile came out, and he said they were just as solid as anything. These were steam cured tile.

Q. Do you use any water at all?

A. We do when we notice they are getting too dry. We cannot steam the room when we are constantly going into and out of it. Now we heat this building with steam. We take the temperature outside into consideration when we turn on the steam heat. If we get it too hot there is no steam inside, and the tile may get dry.

Q. What per cent. of cement do you use?

A. 5 to 1.

Q. How large tile do you make?

A. Twelve-inch, from four to twelve.

On the matter of freezing: We quit one Saturday noon,

and Monday noon I took a four-inch steam cured tile and put it in a pail of water and soaked it well. I then laid it out where the northwest wind could strike it and let it freeze two days. Then I took it into the house and set it by the stove, and when it thawed out it was just the same as before freezing. It was no harder. So I kept it by the stove, dried it, then placed it in a tub of water and soaked it; then dried it, and the tile began to get hard. I have not got a tile in my yard harder than that one became. The freezing seemed to aid the process of hardening.

Q. How does the cost of the 4-inch tile of cement compare with the clay tile?

A. I am not familiar with the cost of clay tile, therefore cannot answer that.

Q. Can you compete with clay tile?

A. We don't know what we are going to do; we aim to get a footing, and none of us make any money.

Q. At what price do you retail four-inch tile?
A. $20.00.
Q. What do clay tile sell at there, same size?
A. $20.50.
Q. Have you ever tried curing cement products by steaming with pressure?
A. No sir, we have not.
Q. Is not that the way they get the good curing by steam, to cure under pressure?
A. I understand that is the way they do when they want to take it out in a very short time after it is put in.
Pres. B.: Are there any other questions?
Q. Has any one had any experience in using cement well curbing?

A. About twenty-five years ago a party came to our place and put in our well a concrete curbing. That well has stood there ever since. Last year we built a sidewalk which ran directly over the top of this well. The curb had to be removed, and it was in a state of perfect preservation. There were no cracks as far as I could see. It has been there twenty-five years.

Mr. G. M. McAllister: I live in Minnesota. Last year I bought a lot of tile, but did not get them all put in in the fall. In the spring, when I wanted to put them in, I had but very few tile left. I would like to ask some who make cement tile if theirs will do the same thing?

A. Will tell you about that next May. Mr. Shadbolt has $7000.00 worth strung out along ditches in just that condition.

Mr. Shadbolt: I am wondering if the $7000.00 will be strung out there when spring comes.

Pres. B.: Mr. P. P. Comoli will now take up the subject

MONOLITHIC CONSTRUCTION AND EXTERIOR FINISH FOR BUILDINGS

To the President and Members of the Convention of the Iowa Association of Cement Users:

Gentlemen: I have been requested to submit a paper upon "Monolithic Construction and Exterior Finish for Buildings," and I take pleasure in submitting the following expressed in my own peculiar way, and trust that what I say may be of some value to the Association.

Cement construction dates back to the time of the Romans. These people secured good results from a mixture of slaked lime, volcanic dust, sand and broken stone. Even this combination, crude in comparison with Portland cement concrete, produced an artificial stone which has stood the test of nearly two thousand years, as evidenced by many works in Rome which are today in a perfect state of preservation.

"Portland cement" is an invention of modern times,—its universal use the matter of a quarter of a century. The honor of discovery belongs to Joseph Aspdin, of Leeds, England, who took out a patent in 1824 for its manufacture. "Portland cement" is so called because of its resemblance in color to a then popular limestone quarried on the Island of Portland.

Manufacture was begun in 1825, but progress was slow until about 1850, when, through improved methods and general recognition of its merits as a building material, commercial success was assured. About this time the manufacture of Portland cement was taken up by the French and Germans, and by reason of their more scientific efforts, both the method of manufacture and quality of the finished product were greatly improved.

Portland cement was first brought to the United States in 1865. It was first manufactured in this country in 1872, but not until 1896 did the annual domestic production reach the million barrel mark, and in 1906 it is safe to state that it had reached fifty million barrels. These figures go to show its adaptability for all kinds of construction and the time seems not far distant when it will supersede most all other material, if it be properly handled by competent workmen.

The making of a home is an epoch in one's career, and before that eventful time comes it is a good thing to make a careful investigation into the relative merits of building materials and to choose those which may insure permanency as well as comfort, architectural beauty and strength. Durability

of materials has at all times distinguished one nation from another, and it will be so for all time. Care and thought are well spent, therefore, in determining of what the walls of a house shall be constructed, and the observing builder has come to acknowledge the superiority of concrete from the view point of economy and comfort.

The economical advantage is always to be considered, and in this case it is certainly obvious on account of its remarkable durability, freedom from decay and the saving in the use of paint. The original cost will, of course, vary according to the location of the property, but it will be found that concrete in many forms can be used nearly as cheaply as perishable wood. Should a house be constructed merely as an investment, a concrete building will be found to outclass all others, since it retains its original value for centuries, while other forms of construction rapidly depreciate.

Comfort is one of the chief requirements of American living and has been found mostly in evidence in a cement concrete house; this because the walls are rendered warmer in the winter, cooler in the summer and more completely sanitary than those built with any other material. The adaptability of cement concrete to any form of construction has been demonstrated to the satisfaction of builders everywhere.

In some states the cost of insurance on a concrete building is extremely low and in many instances owners have ceased to insure,—the dangers from storms, floods and fires being lessened in a proportionate degree. In the monolithic process the concrete is poured into forms and built up where the structure is to stand. This type of structure has been strongly recommended by the highest authority of Europe and of this country. It is known to have withstood the terrific shocks of earthquakes and fire is prevented from reaching the steel to destroy its value.

Solid wall reinforced construction is used in factories, warehouses and structures of like character.

The hollow wall reinforced construction, which has been the occasion of lively interest to those studying modern building methods, consists of tying two walls together with pieces of iron or wire at regular intervals. This style, while more expensive, is considered the best form of construction for all climates as the air space thus formed acts as a barrier to either excessive heat or extreme cold and it can be safely plastered on the inside walls without fear of frost and moisture penetrating them,—advantages which more than offset the slight additional cost.

The best way to build a concrete wall is to set the forms inside and out, leaving the desired space which you intend to

fill. The form should be made of rough lumber, thus giving the concrete a rough exterior surface,—when the forms are removed and it is ready for the finishing coat. This will give a better chance to make a bond to the body. In case trimmings and ornaments of any kind are desired on the outside of a building, the forms can be made of dressed lumber or metal. This ornamental form should be well greased with oil or soapy water or with any other liquid of similar nature. This part of the work will not necessitate any further finish, but will always retain its natural beauty after the rest of the work is done. By this method you can put up your building, remove the forms, and then commence at the top and go down, putting on any class of finish desired and where it is needed, to suit the taste of the owner or architect.

Hollow wall is made in the same manner as the solid wall construction, only the core is built in sections about two feet high and rests on the iron or wire used to tie the walls together. These irons should be long enough to extend half way through each wall and the distance between them will depend on the strength required in the wall. There should, however, be a layer of them every time the core form is raised. The top and ends of this style of wall should be filled solid the last four or six inches, thereby forming a dead-air space. To do any good, this dead-air space must be continuous and not partial. All of this form of construction can be reinforced and adapted to support any kind of floor.

Theoretically and thru experimentation by engineers at experimental stations, governments have obtained a great deal of data as to the value and possibilities of this wonderful material for structural work. Much has been learned regarding aggregates of sand, gravel, or stone and the methods of reinforcement to stand weights and pressures. But there is still plenty of room for practical workers to apply the principles which determine architectural beauty and make for pleasing effect in the exterior finish of buildings.

This class of work cannot all be learned by reading nor by explanation, without either some actual practice on such work, or through a training school, or by apprenticeship as it is done in Europe.

Engineers and architects, experienced in designing this class of work, should be employed in preparing the plans for houses or other large structures, and should co-operate with practical authority to facilitate its construction and to get the best results. There are numerous ways of arriving at this end, and each man in charge of such work must exercise his ingenuity in the use

of the materials at hand, and adopt the method best suited to his requirements.

The methods of finishing on the exterior, such as wood, hollow block, brick, stone and concrete buildings, are various. On all such buildings the outer appearance can be made the same, and if water proofing is needed it can be applied with the best results at this time and the method is very simple and inexpensive. Take a concrete wall or a building as an illustration: First, after the building is constructed and the forms are removed, you must commence from the top in preparing the walls to receive the finish you intend to put on, by wetting the wall thoroughly according to the workman's judgment. Then, mortar of the proportion of two parts sand and one part cement is put on with a plastering trowel, if the wall is sufficiently rough to insure a good bond. But if the surface is too smooth, the mortar must be of a softer consistency and must be put on with force by throwing it with a brick trowel. It reaches the wall in a spattering dash and is allowed to stand until set, thus giving a bond. Then you can proceed by putting it on with a plastering trowel again as in the first case, bring it to an even surface and mark off any design desired, with the proper tools, while the cement is yet in the moist state. If the corner blocks, belt courses, window sills, caps, brackets and all such work are put on, they must be left in a smooth condition and until the entire building is covered.

If a rough coat finish is desired, start over the whole thing again, wetting the wall and preparing more mortar of the proper consistency. This must be put on with a broom made of fine tree limbs. Standing about two feet from the wall, the broom is dipped in the mortar, and then struck with a round piece of wood, held in the other hand. This allows the mortar to reach the wall in a spraying fashion. Repeat this until it comes out in a rough form, but before it hardens clean off the parts where the trimming comes. This makes the trimming look better as the coating which has been over it has bleached it. This operation can go on until the building is completed. By putting water on as soon as it will stand it, no laps will show, nor discoloration from a day's work, nor other defects.

Coloring can be mixed in the cement as desired, with good results. This work can be done in connection with any building material, and will answer as a back ground for the structure, showing off the trimming plainly. No lime should be used.

I trust my remarks have proved of interest and value to you and in conclusion permit me to thank you for your kind attention.

Some discussion followed the presentation of this paper after which the convention adjourned to meet again in the evening.

FOURTH SESSION

Thursday evening, 8 o'clock

Music by the College Glee Club.

President Bingham: The first paper is by Prof. T. H. MacDonald, of the Good Roads Commission of the state. He will speak on the subject

CONCRETE CULVERTS AND BRIDGES

Hindrances and Helps

The important work of such gatherings as this is not altogether the discussion of ways and means of handling materials and labor or of the methods of pursuing work actually begun. There must be a demand from the public, and an intelligent want created throughout the state for the construction which you advocate before there need be any methods of doing the work.

Public Opinion.

The influence of public opinion is one of the chief factors to be enlisted in the behalf of concrete culverts and bridges versus all the other kinds of such structures that are so enthusiastically advertised and advocated. It lies entirely within the possibilities of such a convention to enter upon a work of public education in matters relating to concrete construction. This is very true of work paid for by the private purse, and yet how much more so of work paid for by the public purse. The private individual will acquaint himself with prevailing prices and value, if interested, but the public will accept hearsay many times and be guided accordingly. The real facts in many pieces of public work are often sadly contorted by misconnected rural telephones and misinformed neighborhood councils. This being true it is little wonder that the public officers such as township trustees and county supervisors are slow to respond to their own better judgments, knowing full well that the voters often judge quickly and harshly.

It is a fact, recognized with some personal chagrin, that the work of the Highway Commission has contributed to the defeat at the recent election of a number of most intelligent and honorable supervisors we have known. This has happened because certain reforms have been undertaken, the real significance of which have not been clearly understood. The circumstances of one of these cases is enlightening as showing the influence of public opinion. We prepared plans and specifications for a splendid concrete bridge to take the place of an eighty-foot wood-

en structure. A public letting was held and two bids received, and the contract awarded to the lower bidder at a very reasonable price. The bridge was constructed and is by far the best in the county, but at the fall election the supervisor in charge was defeated by a few votes. The sequel to this tale is the interesting part. The bridge work for the coming year has just been let to the foreman who built the concrete bridge on a percentage basis, bidding for himself while still apparently working for the bridge company by the year. The rumor had been quietly spread among the farmers that there was a discrepancy of several hundred dollars between the real value and the contract price of the bridge, although the letting was public, the contract and specifications on file with the auditor and all the warrants issued in payment published. The real object of spreading such a report was to get a splendid business man off the board and also to win favor with the opposite party. The whole matter is now tied up in the courts. Had the facts and figures been well known and understood by the public, no such occurrences would have been possible, and certainly no such contract for the coming year would have been entered into as was actually done, as the compensation was to be a percentage, based upon the cost of the work, besides other conditions which could not have been fulfilled. With this form of contract there would be no inducements to the foreman in charge to keep down the cost of the work, but on the contrary there would be an incentive to run a large pay roll and to allow waste of material.

Incongruous Designs.

Based upon an incomplete knowledge of the subject, many structures of incongruous design have been built, which have proven expensive and unsatisfactory. This has usually been done where the trustees or supervisors have taken charge of the gangs and put in their own designs. While it is true that steel and concrete, properly used, make an ideal combination, it is equally true that pieces of old iron scattered heterogeneously through the structure would be of considerably more value to the junk dealer than to the bridge builder, and yet some men have wanted to use for reinforcing purposes, small pieces of bolts, rods, gas pipe, and on one occasion an old force pump was offered for this purpose.

Most of the errors are made in the interest of cheapness, but a short investigation will show how this fails to be true economy. For instance, not so very far away is a concrete bridge abutment, the middle part of which was placed upon piling, and the wings upon the soil. The wings have now cracked loose from the abutment proper, as was inevitable from the very nature of

the material. Again there is the case of the bridge abutment that was pushed over in one piece because the base was not wide enough to resist the overturning thrust of the earth. In both these cases the designs were properly prepared, but the supervisor changed them to save, as he thought, in the cost of the work. Practically all the failures can be traced to just such mistakes in design, or else to poor workmanship, as it is infrequent to find any failure due to poor material. One inexperienced man built an eight-foot flat-top culvert which collapsed as soon as the forms were removed. His explanation to the supervisor in charge was that the concrete had been put in on a hot day, and that he thought its quality had been injured thereby. Such an explanation would be ridiculous were it not pathetic that any supervisor would believe such an explanation of a failure, caused undoubtedly by a poor design or faulty construction. Again, there is the case of the bridge company which put in bridge abutments five feet high and four feet wide. This was done on a very simple job but the concrete was paid for at the rate of $13.50 per cubic yard. Such facts as these prejudice the minds of people against a material unexcelled for such purposes.

Verbal Contracts.

It is the exception rather than the rule to find filed in any county complete plans and specifications of the work that is being done. Just at this time it is to the interest of every contractor or builder who is using concrete for public purposes to insist that complete plans, specifications and contracts for such work be on file and open to public inspection. They are the best witnesses if any opposition or discussion arise later. One supervisor contracted for three concrete culverts for a lump sum, specifying the location, but nothing in regard to the length of span, or the design required.

Poor Material.

Another of the hindrances to the best development of concrete construction is the poor material that is being used for the aggregate in some sections of the state. Much sand that is entirely too fine to make concrete is used even when it has to be shipped considerable distances. This is probably due to the fact that crushed stone is not readily obtainable, and its general distribution has not been begun. The actual number of crushing plants in the state is very small and yet there are many places where these could be installed with much profit. Some quarries cannot now be operated at a profit due to the large percentage of waste material which must be handled, which, if run through a crusher, would readily be usable for concrete and road pur-

poses. The saving of cement effected, and the increased quality of the concrete would readily justify a small additional expenditure per yard for stone over that of sand, where the material has to be shipped.

State Crusher Plant.

This opens up an important point of the establishment of crusher plants at the state penitentiary at Anamosa. There is almost unlimited stone which, if crushed, would be valuable for these purposes, and the convict labor could be used in this way so as not to compete with any other established business. For a considerable period much waste stone has been loaded on cars and given to the railroads merely to have it hauled out of the way, and there is no reason why this stone, properly prepared, should not be distributed free of all cost except freight to the counties, especially to those counties where material for concrete and road building cannot be found. A census of the crusher plants of the state shows that the quantity of stone sold to counties for either road or concrete purposes is almost negligible, and such a state crusher would not interfere, as was said before, with any established business. The state of Illinois has in operation now three crusher plants at her penitentiaries. In many cases the railroads accept crushed stone for ballast in payment for the freight. They have also secured very favorable freight rates on stone sent out from these quarries, amounting to one-half cent per ton mile, the minimum charge being twenty-five cents which would deliver the stone to a radius of fifty miles. With crushed stone loaded on board cars at Anamosa and with as favorable freight rates as are already existing in Illinois, the development of concrete work in a number of counties would be much encouraged.

Demonstration Culverts.

The Highway Commission, proceeding on the theory that in many instances "seeing is believing" have helped to construct in various parts of the state small culverts on the request of township [illegible] boards, and this is helping to develop a sentiment for [illegible] construction locally. This is balanced in some cases, however, by the unfavorable impression which some concrete culverts have made when put in by men who do not [illegible] the handling of the material. It would seem a particularly [illegible] task to build a two-foot box culvert, but one recently [illegible] of this size has cracked across the top from end to [illegible] crush with the first heavy load over it.

Plans and Specifications.

Many plans and specifications for ordinary sizes of culverts and bridges have been prepared and sent out to different sections in the state during the past year, and this plan will be followed for the coming year. With the limited appropriation now available the practical construction that can be done and the number of counties that can be visited by the commission is very small, but an attempt has been made to be present when the contracts for the larger structures have been let. There have been instances where the officials on receipt of the plans, acting as foremen in charge of the work, have caused the cost of the completed structures to run very high. This is one of the special hindrances in the work. There is little encouragement to the local cement worker to equip himself for doing county and township work with the knowledge that the trustee or supervisor may take charge of the work. It is entirely opposed to the law and contrary to public policy.

Bulletins.

Such information as has been thought would be practical and timely has been incorporated in the various bulletins issued by the commission on the subject of culverts and bridges, which are for free distribution.

Experimental Work.

There is just now being installed a beam testing machine which will test beams up to thirty feet in length, and a series of experiments have been undertaken to determine the relative efficiencies of different kinds of reinforcing material, such as patented steel, plain steel, and old railroad iron. Another series of tests is being undertaken with sections of culverts having both slab form and arched form. The results of these tests will be published in bulletin form when completed.

President Bingham: The next paper will be

FIELD NOTES OF A CONCRETE GANG

Paper written by Henry Haag, ex-chairman Board of Supervisors, and D. E. Donovan, foreman of the Concrete Gang, Greene County, Iowa.

Five years ago Greene county, by its board of supervisors, decided to put in a few reinforced concrete bridges. They let the first contract to the Marsh Bridge Company for the construction of a bridge over Hardin Creek, consisting of two spans, each

[illegible] extreme length of one hundred [illegible] This bridge [illegible] bridge would have cost. This bridge [illegible] bridge in the [illegible] smaller bridges [illegible] eight-foot wide [illegible] feet high [illegible] twenty-foot waterway [illegible] have been erected [illegible] the same form [illegible] These small bridges were [illegible] The work was [illegible] by the men [illegible] of concrete [illegible] that if more work of this [illegible] they must purchase [illegible] a batch mixer, run by steam engine, and mounted on trucks. During the past season, beginning [illegible] 1906, [illegible] reinforced concrete bridges were constructed in different parts of the county. The aim was to give to each township one of these bridges to be paid for out of the bridge fund, but the work and bridges were so highly appreciated that the board decided to give two such bridges to each township. Three culverts with four-foot waterway, six culverts with six foot waterway, six culverts with eight-foot waterway, one culvert with ten foot waterway, two bridges of fourteen-foot span, and two bridges of sixteen-foot span were built during the season. The board has passed a resolution ordering in fourteen other reinforced bridges for this year. All these bridges in Green county are wider than the ordinary bridge, each having a twenty foot clear roadway with an extreme outside width of twenty two feet. They are all of the type known as the slab or flat top bridge. This form is simple to build, and there is no waste of lumber. The tops of these bridges are from ten inches to twelve inches thick, built of concrete and reinforced with steel rails.

The walls and wings are reinforced with old rods, bars or angles selected from the junk dealer's pile at sixty cents per hundred. The steel rails cost $1.15 per hundred, cut to the [illegible] and delivered to any town in the county [illegible] Where [illegible] stands five feet high or over, reinforced [illegible] A large factor of safety was [illegible] bridges, in fact the steel in the [illegible] carry any ordinary load.

In the matter of gravel, Greene county has distributed here and there in pits and along the banks of the Coon river sufficient good gravel to surface all its roads and to construct its bridges. The river gravel is the best from the fact that it is absolutely clean and free from dirt. Some of the pit gravel is good, but most of it would require washing to take out the dirt and soil. It is a hard matter to state to this meeting just what constitutes a good gravel for concrete, but at least it must be clean and free from earth or soil to make a good quality of concrete. Some gravel, if mixed one to six will make a better concrete than other gravel mixed one to four, and this can only be determined by experience in the use of the same.

No person can make an accurate estimate of what such a bridge is going to cost per cubic yard of concrete, because there are so many factors for or against such cost. For instance, in the matter of excavation for bridge and foundations, in some cases the surface has looked well and yet logs lengthwise and crosswise, old willow roots and stumps and in other cases quick sand have been encountered, which required curbing to allow of excavation to sufficient depth to secure good hard footing. It is invariably necessary to go from two to three feet under the bed of the stream to secure good footings and in several instances four or five feet of excavation has been necessary to secure a solid base. In all foundations the footings have been about two feet wide and as high as need be to get above the water and dirt. In the footings is used considerable broken rock as this cheapens the cost of concrete. The aim is to go sufficiently deep to get below any possible wash, but the streams in Greene county are sluggish and do not wash deep ditches.

Before the foundation concrete sets, steel rods, bars or angles are placed, letting them extend sufficiently high to reach into the floor from three to six inches. After this all forms for the walls, wings and floor are built before any more concrete is put in. No carpenter is employed, every man on the job having been taught to take his certain place in the work and do that particular line of work until the forms are completed. Then every man has his particular place, either in feeding the mixer, attending the boiler, wheeling gravel or broken stone. The foreman at the place of depositing concrete sees that reinforcing goes in at the right time and place. Attention must also be given to the mixing of the concrete to the right consistency; to the manner and way in which it is deposited, and to the sides to see that they are well spaded, in order that the work may be smooth and dense when stripped.

It is a short job to fill in the forms with concrete after they have been constructed. The walls are made from ten to twelve

inches thick, while the wing walls, which run at right angles from the walls, are made one-third as wide at the base as they are high, and are battered up to fourteen inches wide on top, reinforced with heavy steel rods, for which old buggy axles are used. At the corner of walls and wing walls is bent a heavy rod at right angles and laid in to tie walls and wing walls together and make the corner strong, this because the wing walls are ordinarily exposed to a heavy load by the fill on one side with no brace on the outside. A wheel guard is run the full length of the bridge and wing walls twelve inches high and fourteen inches wide, on top of which is built a hand rail if required.

The concrete is used plastic or in a slush form which requires no tamping to fill all voids and air spaces. This makes a denser concrete. It was not the aim to see how cheaply these bridges could be built, but how well they could be made without profit to anyone, and with a conservative expenditure of money from the road funds. One of the most expensive bridges constructed this past summer has a sixteen foot clear waterway, twenty-two feet wide with wing walls eight feet long. The foundations are four feet deep and two and one-half feet wide. The walls on top of the foundations are seven feet high, eighteen inches wide at the base, and battered up to fourteen inches at the top for wings and twelve inches at top for walls. The floor is twenty-two feet by eighteen feet, one foot thick. The wheel guard is twelve inches thick by fourteen inches wide and thirty-two feet long. The itemized cost of this bridge is as follows:

70	yards river gravel at	$ .70	$ 49.00
75	bbls. cement at	2.20	165.00
10	yards broken rock at	.70	7.00
20	steel rails 18′, 7000 lbs. at	1.15	80.50
1000	lbs. junk rods at	.60	6.00
	Excavation for 2 days, gang at	14.00	28.00
	Putting in concrete foundation $\frac{3}{4}$ day at	14.00	10.00
	Building forms, $1\frac{1}{2}$ days at	14.00	21.00
	Filling forms with concrete, 2 days at	14.00	28.00
1000	lbs. coal at	4.00	2.00
15	lbs. nails at	.03	.45
	Hauling lumber-tools to bridge and back at	14.00	8.00
	Hauling cement and tools		18.00
	Lumber wasted, 200 feet at	29.00	5.80
	Taking off forms		2.30
	Total cost		$431.05

The cost of the concrete in this bridge was $5.90 per cubic

yard, there being seventy-three cubic yards of concrete in the bridge, as follows:

Cement	$2.26
Steel	1.22
Lumber	.22
Gravel and stone	.76
Labor	1.41
Coal	.03
	$5.90 per cubic yd.

In this job the bank caved in, causing an extra expense for removing the earth. The gravel used in this bridge was very good clean river gravel.

Wherever possible the back wall of earth was used for the walls, thus saving one wall of lumber. As soon as the concrete was all in, the teamster and men pulled out for the next job, the foremen remaining to trowel up the work and barricade the bridge to keep the travel off for two or three days. After three days the false work was generally removed from the hand rail, outside walls and wings, but that under the floor was permitted to remain for thirty or forty days. Travel was permitted over the bridge after three or four days.

After a few days new concrete takes on a different appearance. It goes through a sweating period, lasting about ten days, during which time the concrete is very brittle, and the inexperienced person might think the concrete was not good. However, if left undisturbed it soon begins to take on its permanent set, and at the end of thirty days is sufficiently hardened for all ordinary purposes. From this time on its strength increases with age until it is practically indestructible.

At the beginning of the season a good set of men was employed, at $1.50 per day and board. These men were retained throughout the season and they learned to do the work in a systematic manner. Each man knew what was expected of him, and learned how to take hold of the work to make it move rapidly and to gain time.

At the head of the gang there must be a man who is proficient in the work and who understands all the details of the work and material as the same conditions will not exist in any two jobs. In moving from place to place all over the county, one brand of cement will be found at one bridge and another brand at another bridge. The gravel is frequently of different size and quality, and requires experience to determine how it shall be mixed. Such a foreman must be a hustler if he expects to make a good showing at the end of the season.

Speed is one of the important factors in a concrete mixer. It enables one to deposit the concrete in the forms before the preceding batch has set, and it is essential that the slab or flat top be made all in one piece, and in a short space of time, thereby allowing it to set all together without seams.

Concrete work requires that the men be absolutely honest with the work. They cannot cheat the work without cheating themselves, for the finished work will render the verdict.

The average cost of the concrete put in during the past year in Greene county was $6.25 per cubic yard.

A number of slides were shown pertaining to the bridge work in Greene county. Discussion during the presentation of the views.

Q. Do you keep your wing walls down the same depth with the abutments?

Mr. Donovan: We do not always do that. They always vary a little bit.

Q. Do you try to get your abutments down below the frost line or wash line?

A. The wash line.

Q. What kind of a spade do you use?

A. I have a special spade that I made myself. It has a 24-inch blade, straight handle.

Q. How do you tie your frames together?

A. Simply use No. 12 wire and double it.

Pres. B.: Now are there any questions that have not been asked during the progress of the reading of the paper and the using of the slides in regard to the making of these highway culverts?

Q. What is thickness of the concrete in your four foot culverts?

A. Six or seven inches.

Q. I would like to ask Mr. Donovan about putting in those coffer-dams in places where he had to shut out soft mud?

A. In Greene county quick sand is about the only thing we come in contact with. The building of the coffer-dam depends on the conditions; I never built two alike.

Pres. B.: In making the culverts you describe, the proportions were 1 to 4, to 1 to 6?

A. Yes, ordinarily, I believe.

Q. Have you had any trouble from the contraction and expansion of the heavy iron?

A. No, sir.

Pres. B.: The committee has arranged for an additional number on the program, a little sociability, with light refreshments, and I believe we are now ready for that. We will adjourn until tomorrow morning.

FIFTH SESSION

Friday morning, January 25, 9 o'clock.

Pres. Bingham: Convention will come to order. I will ask if Mr. Metzgar of Grundy Center is present? In Mr. Metzgar's absence, Mr. Roman of Clinton has kindly consented to discuss the subject of Mr. Metzgar's paper, "Cement Stock Watering Tanks." Is Mr. Roman in the room?

Mr. Roman: Mr. Chairman, Gentlemen of the Convention: I am from Clinton, Iowa, and before I tell you the little I know, I want to tell you something about my county. I live in a county where most of the farmers are stock men; every farm has one or two windmills, and many stock in their yards. They therefore have a good many stock tanks. I started out five years ago to make stock tanks. The first I built were square tanks, and they were very satisfactory. I believed a round tank would be much better, be stronger, and look better. I got up two sets of circular steel plates, each plate 30 inches high. The outer circle had five plates, the inner, four. I reinforced the top and bottom by iron bands, 1¼ inches wide. I can set these up in about 15 minutes. After the concrete is in place, I leave the forms stand for 24 hours. It makes a very neat looking tank, and gives perfect satisfaction. I reinforce the circular tanks with all the way from 1 to 4 iron bands. A great many times the tanks are small, and I place the iron bands that I use about two inches below the top.

Q. What size do you make?

Mr. R. Mostly ten feet in diameter on the inside; 2 feet deep.

Q. What do you get for a tank?

A. $25.00. The farmer hauls the material; I furnish the cement.

Q. Do you use water-proofing?

A. I never use any water-proofing whatever, and I have never had a tank leak nor crack.

Q. You make the circle first, and put in the floor afterwards?

A. Yes; you can put in the floor first, but it is more trouble, and would not be any better.

Q. Do you pay any attention to frost?

A. No, sir.

Q. How thick do you make the bottom?

A. Drop down to about a foot in the center, but on the sides about 30 inches.

Q. When you were making square tanks, what size did you make them?

A. 6 by 12, 6 by 10, and down as low as what we call horse troughs, 2 by 6 and 2½ by 6.

Q. In making narrow horse troughs, did you have any trouble in their breaking?

A. Never had any trouble.

Q. How thick did you make the walls?

A. Six inches, sometimes five. Never go below five. In making the horse troughs, I used to put in a little iron, bent to an angle for reinforcing the corners.

Q. Do you use slush mortar?

A. Yes, sir, never use dry where I can use the wet work.

Pres. B. We are very much obliged to you, Mr. Roman, for filling in this space. We will now have a paper by Mr. E. Kenney, of Creston, on

CEMENT SIDEWALK EXPERIENCES

Mr. Kenney: Mr. Chairman, Gentlemen of the Convention: The financial aspect of this question is what I would like first to present to you. I take it that the most of us are in this business for the money, for the making of a living. And we are not quite satisfied if the emoluments growing out of it are not on the increase. In other words the object to be attained is to put our business on a sound financial basis.

The making of the cement sidewalk has passed the experimental stage. Properly constructed, it is not a fraud or a humbug. Indeed, I suppose it is the opinion of a majority of the people of this country that Portland cement concrete is the very best substance of which sidewalks can be made; an opinion that probably did not exist fifteen years ago.

I am often asked how long a well constructed sidewalk ought to last. Such a question of course can not be definitely answered. Absolute permanence does not apply to any of the works of man. But what most people expect and what they have a right to expect, is that it shall possess as much permanence as a well constructed building. For instance this building will last twenty-five or thirty years. It will show age, but that will not detract any from the appearance of it. It will look rather nicer than it does now, when it is a little moss grown. And thus our sidewalks should appear.

As to material, I have a pretty well defined idea of the least amount required to do work of the kind and permanence I have just tried to describe. The sidewalks on these grounds are not good enough, they are put too low in the ground to look well.

Snow and dirt will pile up on them. If they had been put four inches higher, and gradually sloped back three or four feet, they would last a much longer time. This is not practical in streets. We have to put sidewalks where the city engineer states, as a general thing.

One reason why I am here is to learn whether I shall use more or less material in the construction of my work. I well remember eighteen years ago, my first experience with cement sidewalks. I was plastering a house. I supposed I could not make sidewalks, because I had not seen any made. But a fellow said he would tell me how to do it. I took some cement and made concrete of it, and he told me to lay papers on the side. So we nailed papers on the side, and it was a pretty bum looking job; didn't get the papers straight. We made it about four inches thick, mostly out of Louisville cement. It was made of pretty wet mortar. I looked at that job the other day, and there is only one broken block in it. But I was not satisfied. So I took a trip to Des Moines, and peeked around, and stole some ideas, which is the way most of us, I believe, have learned our trade.

With the aid of a blackboard, I will try to outline what I would consider good safe work. To better describe it, I shall divide it into three general classes, business, residence, and yard walks. As a general principle, the larger the block, the better the work should be. Perhaps a little less material might answer. But there is a text of Scripture that might apply to sidewalk business, as well as to a good many other kinds of work: "Enter ye in by the narrow gate, for wide is the gate, and broad is the way that leadeth to destruction, and many there be that go in thereat, for narrow is the gate, and straight the way, that leadeth unto life, and few there be that find it."

In the sidewalk business, the way to business destruction is the use of too much or too little material, more often the latter.

In the matter of price, the same invariable rule will hold good. If the price is too high, you invite competition. If too low, you can't pay your bills. Another thing in regard to price, I would like to emphasize, and that is uniformity.

Our honorable governor, in his message to the legislature, talked of an equality of railroad fares and freight charges, which might well apply to the sidewalk business. I do not mean that there should be a combination between different contractors. People are so constituted that they will not cheerfully pay to one man more for a piece of work than others are paying for the same. Of course there is a temptation to do large blocks of work at a less price than smaller jobs, and perhaps absolute uniformity cannot be reached. But if there is such discrimination, it should be openly made.

... of a guarantee has been to me another vexing ... asked very often if I guarantee my work, and I ... in the affirmative. There are some who ask a ... for a term of years. I am rather of the opinion ... not well to grant such a request, further than to ... work should be good and durable. I think that it ... to have business cards with a guarantee which ... the form of a contract. Such a guarantee should ... good, where the defect is clearly the fault of the con... When the use of cement concrete has become as firmly established for sidewalks as it is for other purposes, guarantees ... not be expected.

In regard to the use of water in concrete, I am inclined to the opinion that I have used too little in the past, and shall use so much that when well tamped it will rise to the surface. I regard this of very great importance.

I would say, also that I would much rather have river gravel than any broken stone that I have been able to obtain. I feel very certain about this matter, although there is quite a wide-spread idea among the sidewalk men that broken stone is the thing. This is a great mistake, and cannot be too strongly condemned.

DISCUSSION

Q. How wet do you make your concrete for walks?

Mr. K.: I make it just a little bit wetter than the block men want concrete for their blocks. I use more water than I have used in the past. I want enough water so that when tamped, it will appear on the surface.

Q. What kind of foundations do you make?

Mr. K.: That is something that I have not considered so very important. If I have black soil, a little bit of sand, an inch or so, I would consider sufficient foundation. But if there is wet clay, three or four inches of cinders seem necessary. There is not much use of putting cinders in unless you can provide drainage, so the water won't stand there.

Q. Is your work done by city contract, or private individuals?

Mr. K.: Mostly by private individuals.

Q. What do you get for that work?

Mr. K.: Thirteen cents where the job is a full city block long, or fourteen cents where I have just a single block. I am ... a little doubtful about the advisability of two prices, as I have heretofore made. I believe it is better to have but one price, or as near one price as possible.

Q. What do you pay for cement?

A. I got my cement last year from $1.85, ran up to $2.15, and then back again to $1.90.

Q. Would it not be better to use more material and get more for your work?

A. Yes, I believe it would.

Q. Do you think ½-inch top as good as ¾ or a little better?

A. Well, if you put extra cement into the work, I believe that it would be better. I do not see any necessity for making a very heavy top.

Q. How wet do you make the top?

A. Just mortar like plaster.

Q. Do you guarantee your work?

A. I guarantee my work, but do not have a written guaranty, because, if you do not do this with everybody, it isn't fair. I tell them I will do the work good, and where it doesn't turn out well, will replace it free of cost.

Q. How long do you consider a walk ought to stand before being used, and do you believe in running water over or floating your walk after four or five hours to harden it?

A. Life is too short to do that. I cover it when I can, and under the hot sun, I sprinkle water over it, but in ordinary weather, I do not bother about that.

Q. How soon do you allow them to use the walk?

A. I like to keep them off it four days, but sometimes it will be all right in three days.

Pres. B.: We have only got started on this sidewalk discussion, but we must take up the next subject. The next number on the program is

TESTS OF CEMENT MORTAR AND OF CONCRETE BUILDING BLOCKS

By A. Marston and M. I. Evinger.

Prof. Marston: I will say that the paper I present will be brief. The tests themselves are not as extensive as we had planned, and I must make that apology in the beginning. They are not extensive enough to make it wise to draw too many conclusions from them.

PART I.

Tests of the effects of ensilage, manure, sheep dips and cinders upon the strength of cement mortars.

These tests were undertaken mainly because the college has been receiving so many requests for information as to whether cement could be used safely for the construction of silos, stable

floors, and dipping tanks on the farm. There was some question also, as to whether layers of cinders on top of the reinforced concrete roofs of septic tanks would have an injurious effect upon their strength and as to whether manure placed upon cement sidewalks to prevent freezing would be injurious.

The tests were made by Messrs. H. M. Hansen and F. M. Sloane, senior civil engineers at the Iowa State College 1905-6, as thesis work. The tests were made in accordance with the standard specifications of the American Society of Civil Engineers. All briquets were made of one part of Iola Portland cement to three parts of standard sand.

The results of the tests are given in Table No. 1 herewith:

TABLE I.

STRENGTH OF CEMENT BRIQUETS KEPT IN CONTACT WITH VARIOUS MATERIALS.

Note: Proportions= 1 :3 in all briquets.

Kept in Contact with	Age	Tensile Strength Lbs. per Sq. In.		
		Minimum	Maximum	Average 20 Specimens
Water	7 days	160	220	185
"	28 days	264	364	318
"	3 mos.	297	460	371
"	6 mos.	370	440	406
Manure	*7 days	130	260	186
"	28 days	215	376	283
"	3 mos.	320	434	373
"	6 mos.	390	440	421
Ensilage	7 days	180	270	214
"	28 days	285	385	328
"	3 mos.	314	452	384
"	6 mos.	375	425	399
Lime & sulphur	7 days	150	250	196
"	28 days	190	356	253
"	3 mos.	186	308	248
"	6 mos.	350	450	402
Creosote	7 days	135	210	169
"	28 days	233	335	290
"	3 mos.	291	415	343
"	6 mos.	375	435	410
Cinders	7 days	*134	224	179
"	28 days	245	365	294
"	3 mos.	278	430	347
"	6 mos.	350	430	390

* Frozen.

Study of Table No. I will show very little effect, in the long time tests, of any of the various materials investigated.

The briquettes tested for the effect of ensilage were kept packed in the material in one of the college silos. For the manure and cinders tests the briquettes were buried in heaps of the materials. The manure was from a horse stable. For the sheep dip tests the briquettes were kept immersed in the dip solutions. Two dips were tested, one a solution of lime and sulphur, and the other a creosote dip.

The tests are too few and imperfect to be conclusive but so far as they go they indicate entire safety, so far as strength is concerned, in using cement for stable floors, silos and dipping tanks on the farm, and in covering cement with manure or cinders whenever desired for any purpose.

PART II.

The tests of cement blocks were planned to be more elaborate and extensive than the few results we now have to report would indicate. In fact, the tests already made must be regarded as merely preliminary to a much more extensive and reliable investigation.

The results of the tests completed are given in Table No. II below:

TABLE II.

TESTS OF STRENGTH OF CONCRETE BLOCKS.

Manufactured by R. A. Furrow and R. R. Palmer.

No. Sample	Proportion	Age	Size	Distance Between Sup.	Transverse Test—Ultimate Load Lbs. per Block		Modulus of Rupture—Lbs. per Block			Crushing Test—Lbs. per Block		
					Air Cured	Water Cured	Air Cur'd	Water Cured	Air and W't'r Cur'd	Air Cured	Water Cured	Air and Water Cured
2	1:3	2 wk	12x9x24″	18″	5700	5100	305	272	288	1690	1810	1750
2	1:3	4 wk	12x9x24″	18″	6400	6700	340	357	348	1820	1780	1800
2	1:3	3 mo	12x9x24″	18″	11550	8650	616	461	538	2210	2910	2560
2	1:4	2 wk	12x9x24″	18″	5250	5550	280	297	288	1900	2360	2130
2	1:4	4 wk	12x9x24″	18″	7800	7150	416	381	398	1920	1800	1860
2	1:4	3 mo	12x9x24″	18″	9300	7750	447	408	427	2700	2380	2540
2	1:5	2 wk	12x9x24″	18″	4950	5100	264	274	269	1030	1187	1110
2	1:5	4 wk	12x9x24″	18″	4100	6500	219	347	283	1540	1480	1510
2	1:5	3 mo	12x9x24″	18″	9250	10450	494	607	550	2020	2220	2120
2	1:6	2 wk	12x9x24″	18″	4200	4200	250	225	237	840	1060	950
2	1:6	4 wk	12x9x24″	18″	4400	*5000	235	*267	246	1660	* 480	1270
1	1:6	3 mo	12x9x24″	18″	8000		427		427	2050		2050

* 1 sample.

The tests were made as thesis work by Messrs. R. A. Furrow and R. R. Palmer, senior civil engineering students at the Iowa State College, 1905-6.

The blocks were made on a Miracle machine, by the students aided by a workman from the cement block factory of H. L. Munn & Co. The gravel was from the college pit, but was not nearly as good as that reported upon at this meeting by Mr. M. J. Reinhart.

The tests shown in Table II are not considered numerous or reliable enough to warrant drawing any general conclusions. Note the abnormally high transverse strength of the 1 to 5, 3 mos. specimens.

So far as they go, the tests show little difference in strength due to curing under water, but it should be noted that the air cured specimens were kept in a moist basement and were frequently sprinkled. These tests go to show that where the blocks are thoroughly protected from sun and wind, and where the sprinkling is thoroughly done, they can be made as good by air as by water curing. The danger in air curing is lack of sufficiently intelligent and faithful care.

The tests also show a general diminution of strength with decrease in the proportion of cement used, but are too few in number to entirely mask other causes of variation in strength.

Perhaps the most striking fact brought out by the tests is the very rapid increase of strength with age. Blocks are yet to be broken in the same series of six months, one year, and two years ages respectively.

Pres. B. Are there any questions in regard to this testing of cement blocks?

Q. Was this a tamped block?

Prof. M. Yes.

Q. Was there any record made of the consistency of the tamp? Was there anything done to ascertain the solidity of the block?

A. No, there was not. I think perhaps that is something we should have done. They were made at the factory, and I suppose were tamped the same as ordinary blocks.

Pres. B. What proportion of the cement users in the audience this morning have used salt?

(Twelve or fifteen hold up their hands).

Q. I would like to ask if any steam curing was used in these tests?

A. No, we hope to do this.

Q. Have you used any hydrated lime in the tests?

A. No, we have not tried that.

Q. What influence does salt exert on the mass?

Prof. M.: I do not believe I can answer that question. Some Portland cements will stand the effect of sea water. I cannot tell just what the chemical action is. I had quite an interesting experience with the new Central building. No salt was used in the concrete there, but it turned very cold after they started to work in the spring, and one section of the reinforced work froze solid, and stayed so for quite a while, as I recall it, a week or more. When it thawed out, the concrete was still soft. I thought it would be of no value and would have to be taken out, but it hardened up in the course of three or four weeks and we tested it, the same as the other parts of the floor, 500 pounds per square foot. That particular job we kept track of, and it really showed less signs of failure than some that had not been frozen.

Pres. B.: While we are speaking of salt, I want to say, I have heard it stated that if salt is used in mixing concrete, it is not suitable for barn floors; that the action of the ammonia with the salt is detrimental to the concrete.

Mr. Ireland: It does not show any bad effects. In Chicago in the big livery barns the floors are all of concrete.

Pres. B.: Do you know that salt was used in mixing that concrete?

Mr. Ireland: Yes sir, it was.

Do you carry the tests far enough to know when cement reaches its ultimate strength?

Prof. Marston: I am younger than I look, and I have not yet carried it that far.

Q. I would like to ask if the slush method is being used.

Prof. Marston: We would like to try that. Mr. Evinger, the gentleman who wrote this paper, is really the man who should have read it, but he claimed his voice was out of working order. He plans to go ahead with some work of this kind.

Pres. B.: If there is no further discussion, we will take up the next paper. Mr. Fuller is unable to be present, but his paper is here, and will be read.

SELECTING THE PROPORTIONS FOR CONCRETE

By William B. Fuller, consulting civil engineer, 170 Broadway, New York City.

The growing use of concrete for structures in which great care must be taken to have only the best material and workmanship, has stimulated investigations into the effect of varying the relative proportions of sand and stone in the mix, the propor-

tion of cement to the total remaining the same, and the result has demonstrated very conclusively that the proper grading and relative proportion of the ingredients, has a great influence on the quality of the concrete produced. To demonstrate this great effect, the writer at one time made up a set of beams six inches square and six feet long, varying these relations very widely from almost all stone to almost all sand, and broke the beams after thirty days with the following results:

Proportions.	Modulus of Rupture. Lbs. sq. in.
1 : 2 : 6	319
1 : 3 : 5	285
1 : 4 : 4	209
1 : 5 : 3	151
1 : 6 : 2	102
1 : 8 : 0	41

By inspecting the above table it is seen that although the amount of cement in each of the above beams was the same (namely $\frac{1}{9}$ of the total material), some of the beams were over 700 per cent stronger than others.

In investigating this subject over a term of years, it has been found that there is one combination of any given sand and stone which with a given percentage of cement makes the strongest concrete and this is the proportion which also gives the densest concrete, that is, the concrete which contains the least percentage of voids, or otherwise, that which weighs most per cubic foot.

It is found also that this dense concrete is least permeable to water and consequently is the most durable, and it is also found that as a practical advantage such concrete is most easy to place, working "slick" and filling up all voids and bad corners.

The above stated law that the densest concrete is also the strongest gives a very easy way of proportioning the materials at hand so as to obtain the best and strongest concrete possible with these given materials. That is, to obtain these proportions by trial, as follows:

Procure a piece of steel pipe 8 to 12 inches in diameter and about a foot long and close off one end, also obtain an accurate weighing scale. Weigh out any proportions selected at random, of cement, sand and stone, and of such quantity as will fill the pipe about three-quarters full, and mix thoroughly with water on an impervious platform, such as a sheet of iron; then, standing the pipe on end, put all the concrete in the pipe, tamping it thoroughly, and when all is in measure and record the depth

of the concrete in the pipe. Now throw this concrete away, clean the pipe and tools and make up another batch with the total weight of cement, sand and stone the same as before but with the proportions of the sand to the stone slightly different. Mix and place as before and measure and record the depth in the pipe, and if the depth in the pipe is less and the concrete still looks nice and works well, this is a better mixture than the first. Continue trying in this way until the proportion has been found which will give the least depth in the pipe. This simply shows that the same amount of material is being compacted into a smaller space and that consequently the concrete is more dense. Of course, exactly similar materials must be used as are to be used on the work, and after having in this way decided on the proportions to be used on the work it is desirable to make such trials several times while the work is in progress, to be sure there is no great change in materials, or, if there is any change, to determine the corresponding change in the proportions.

The above described method of obtaining proportions does not take very much time, is not difficult, and a little trouble taken in this way will often be productive of very important results over the guess method of deciding proportions so universally prevalent. I have repeatedly known concrete to be increased in strength fully 100 per cent by simply changing the proportions of sand to stone as indicated by the above method and not changing the amount of cement used in the least.

A person interested in this method of proportioning will find on trial that other sands and stones available in the vicinity will give other depths in the pipe, and it is probable that by looking around and obtaining the best available materials the strength of the concrete obtainable will be very materially increased.

As a guide to obtaining the best concrete, the proportion of cement remaining the same, the following are the results of extensive tests:

The stone should all be of one size or should be evenly graded from fine to coarse, as an excessive amount of the fine or middle sizes is very harmful to strength.

All of the fine material smaller in diameter than one-tenth of the diameter of the largest stone should be screened out from the stone.

The diameter of the largest grains of sand should not exceed one-tenth of the diameter of the largest stone.

The coarser the stone used the coarser the sand must be, and the stronger, more dense and watertight the properly proportioned work becomes.

When small stones only are used the sand must be fine and a larger proportion of cement must be used to obtain equal strength.

QUESTION BOX

Pres. B.: Mr. Coutts, there are two or three questions in the box. We might have them taken up now.

Mr. Coutts: Well, I admit I am stuck on the very first one I get hold of. The question is, "What is quicksand?" There is only one answer that I can give. It is material that gets every contractor into trouble that comes into contact with it. If any one can give us a technical answer to this question, or an answer that will be what the party who asked the question desires, I will be glad to have him speak right out.

Remark. Describe it, Mr. Coutts; what does it seem to be?

Mr. Coutts: It looks like sand. I have had a few experiences with quicksand. I remember that it kept one or two men busy digging out the man standing where the sand was, to keep him from going out of sight.

Pres. B.: Mr. Donovan, what is quicksand?

Mr. Donovan: I don't know. I have seen quicksand mixed with blue mud, about as thick as molasses in cold weather, and I have seen quicksand almost as clean as if it had been washed with water, and as fine as flour. I don't know.

2nd Question: Can the tamped tile of the sizes 14 to 18 inches in diameter compete with the clay product of same dimensions; that is, placed f. o. b. cars at destination?

Mr. Coutts: Will some tile man who knows about this, answer this question?

Answer: Yes, sir, you can.

3rd Question: What is the difference in the crushing strength of a concrete tile reinforced with one wire and a concrete tile of the same diameter, without reinforcement?

Mr. Seafert: Depends upon where you put your reinforcement.

4th Question: Is it advisable to wash sand; if so, under what conditions, and what is the most economical method of doing the work?

Answer: It is advisable to wash sand if you have dirt enough to make flaws in the concrete. As to the most economical method of washing it, I am unable to say.

5th Question: Please give us the amount of cement drain tile used in the different counties in Iowa in 1906, for the reason that three-fourths of our customers tell us that they are a new thing and they want some one else to use them first.

Mr. Coutts: I have not got statistics; I presume a great many were used.

Prof. Beyer: We compile annually the statistics, and two years ago, you remember, cards were mailed to the members that were here and to many others. That card asked for statistics of production of different kinds of cement products. The returns were very, very meager. I should like to repeat that this year, if I have any encouragement. We have an arrangement so that we can bear the expense of it if you will take the trouble to make a list of the users in your home locality. That is the only way we have of getting the addresses. If you will do your part, we will do ours, and report later on, as soon as statistics can be secured for 1906.

6th Question: How thick should a curb be made without gutter? How deep in the ground? Should it be made in blocks, or solid?

Mr. Fulkerson: Depends on how much exposure there is on the curbing. It should be about 10 per cent more below the ground than sticks up above the ground.

Q. How thick?

Mr. Fulkerson: Depends on the curb, and how much exposure. For a 5-inch exposure, a 4-inch curb is heavy enough; for 10-inch exposure you want six inches.

Q. Do you think it should be two-thirds in the ground?

Mr. Fulkerson: It will do no harm to have it two-thirds in the ground. It depends on the nature of the soil, and whether it has pavement against it.

7th Question: Is it practical to make a cement tile by machine as large as eighteen inches in diameter?

8th Question: Is it better to sift neat cement on top of a sidewalk or not?

A. I say not.

Pres. Bingham: We will now go back to the start of our program, and have the **Notes** on the **Investigations** of **Cement Mortars** and **Concretes** at the U. S. Geological Survey Laboratories at St. Louis, by President R. L. Humphrey, of the National Association of Cement Users.

President Humphrey: Mr. President, and members of the Iowa Association of Cement Users: The work that has been going on in St. Louis has been a great deal talked about. Very little has been said in the way of results, and I have no doubt that people are beginning to be skeptical as to whether or not they are actually doing anything at St. Louis. The original appropriation was $5000.00 to carry on the work until June, last year. During that time it was necessary to get equipment and apparatus to carry on some preliminary experiments. The results of the studies of sands, gravels and crushed stone have

been compiled, are in press, and I presume a bulletin will appear in a very short time.

In June of last year, in response to resolutions passed by various state societies and other organizations, congress appropriated $100,000.00 for the investigations of structural materials. Under action of the Advisory Board it was decided that the money should be spent entirely for the investigation of cement, mortars, and concretes. In order to carry on the work on such a comprehensive scale, it was necessary to get a great deal of additional equipment. During the fall, we have equipped and installed what is perhaps the largest, and certainly the best testing laboratory in this country, if not in the world. We have some forty-odd men engaged in testing concrete in all its various forms. We have six large testing machines, and one of them which is in process of construction will be the largest testing machine in the world.

Now we have been working steadily; we have been testing sands, gravels, crushed stones from all over the country. Then we have been making tests of concrete. One series of these tests makes use of over six hundred beams, each 12 feet long, 8 by 11 inches, nearly double the total number of beams that has yet been made in this country. In addition to that, we have been testing the permanence of cements, that is the methods applied to make them dense and waterproof. We have also been carrying on a series of tests to get the strength of concrete in shear and compression. And then, what will interest you, we have been carrying on a series of tests of concrete blocks. We have some seven different types of machines, representing various styles, and have made considerably over one thousand concrete blocks. Many of these have been tested for their fire resisting qualities.

We made up of each class of blocks a double series, one-half of which was tested for physical strength, and the other half for fire resisting qualities. Each after its fire test was again tested for physical strength. Now we have learned a great deal in the way of testing concrete blocks. Simple as it may seem to make a concrete block, it is as a matter of fact very difficult to make a good one; and one of the things I hope is that this work will produce a series of rules or statements which will lead you all to make a block that will meet the physical requirements of a building, and will offer great resistance to fire, and be a dense, waterproof product.

We are taking ordinary sand and crushed stone of various types, and treating the blocks in various ways. We have a chamber in which the blocks are placed, where we study the

affect of high pressure steam. We have found out a great many interesting things about the process of steam curing. You can take a block after it is made, place it in a steam chamber, and the block will soon be so soft it will come to pieces like sand. You can take a block and put it in the steam chamber after it has hardened a reasonable length of time, and you can so dry it out by steam as to take a great portion of its strength away. But you can also put a block into an atmosphere of steam, and you can cure it in 24 hours so it will have a strength which in normal summer weather it would not attain in a week, and in winter weather, would take a month or more. The essential requirement is simply this, that your steam must contain moisture, and must be wet. If it is not saturated with moisture, it will take the moisture out of the block, and the block will be deprived of the means of hardening; and if it is not already set, this taking away of the water will prevent setting, and the temperature may be hot enough to take away the moisture before it has set, and the block will come to pieces. The remedy is to supply the water required, and the heat will hasten the process so that the blocks will harden much more rapidly. We are carrying on tests in that way, and soon are going to publish the results in a bulletin.

I have a series of slides here which will be interesting, and will give you views of the fire tests which we have been making. These tests have been made in the laboratories of the Insurance Underwriter's Association in Chicago, in their special furnace. The laboratory will soon possess its own furnace, and will be able to carry on its investigations in its own way. The difficulty now is that we must confine our tests so that they will fit in with the regular tests, and it often proves especially hard, because we try to make the tests on the day they fall due.

A series of twenty-three excellent views were shown of the different sections of the St. Louis Testing plant, and of the fire tests being conducted in the Chicago laboratories. As the views were shown on the screen, Mr. Humphrey gave many details regarding the machines, instruments, and other equipment, and the methods of investigation that are being followed in making the tests.

The blocks tested for fire resistance were made by each the dry, medium and wet processes. After removal from the furnace, they were quenched with a jet of water.

DISCUSSION

Mr. H.: The question has been raised as to why we used 1700 degrees F. for the test. The insurance people have insisted

on certain requirements, and we have in deference to their wishes, made the tests of this character. A water pyrometer is used to measure the temperature. We have got to make material which will stand firing. I am sure the work we are doing at St. Louis will go a long way toward giving you the information you desire.

I want to take this occasion to thank you for the attention with which you have listened to me. I hope that before the convention closes, you will show your appreciation of the work which we are doing in St. Louis by passing resolutions, as the National Association did, petitioning congress for a continuation of this work. We are now well started, and with the appropriation of $100,000.00 this year, which we are sure we will get, we can go on with the work and give you more results. I want to thank you again for your attention.

Mr. Coutts: I would like to ask if the same piece of masonry stood under all those tests. I think there were four tests and the slabs showed the same condition of brick masonry all the way through.

Mr. H.: The same brick passed through all those tests.

Q. What was the proportion of cement and sand?

Mr. H.: 1 to 3 and 1 to 4. All the tests you saw were 1 to 3, one part cement to three of sand.

Q. How old were the oldest blocks in these tests?

Mr. H.: The tests were all made at the same period, 60 days. May have varied a day or two, but were practically 60 days.

Q. What block did the Association think stood best the quenching with water, the dry, medium, or wet block?

Mr. H.: So far as we have gone, I think it would be hardly fair to draw conclusions. The blocks were green at 60 days. If anything, it seemed that the medium or wet block showed up a little better than the dry, but there was not enough difference to amount to anything. Of course at 1700 degrees most any concrete will lose its water and the surface will scale off. The point we are trying to develop is to find out what material is necessary to place around the steel to protect it, or the surface that carries the load, from the action of the heat. Concrete is a very poor conductor of heat. That is one of the good qualities of the material.

Pres. B.: I noticed a seeming difference in color of the dry, wet and medium blocks, the dry being the darker; was that just fancy, or true?

Mr. H.: That probably was the fault of the views.

Q. Were these steam cured?

Mr. H.: They were steam cured, and treated by our spraying process.

Q. Were the wet blocks made of slush, or were they mortar that you could handle?

Mr. H.: Well, they are handled in the machine, and could not be slush such as we know the ordinary concrete to be.

Q. You spoke of making tests of water proof blocks.

A. The work along that line has been going on about two months, too short a time to be able to make any statements.

Pres. B.: The committee on legislation has a report to make at this time.

Mr. Coutts: Just a statement I desire to make. I find that I must leave right after noon. Our committee on legislation had a meeting this morning, and the state of Iowa wishes to add in a small way to what Mr. Humphrey has just been telling us the United States is doing on a larger scale. Last year this association committee met jointly with the committee of the Iowa Brick and Tile Association, and we drafted a bill to present to the legislature for the purpose of starting a school of ceramics to take this matter up. It was a special session and things were conducted in a great deal of a hurry. There were several matters before the house, and we seemed to catch the legislature in a bad humor. It was the judgment of the joint committee that if we got anything through, it would have to be something preliminary, without any appropriation attached to it. The bill was put through with this unfortunate defect. There has been nothing done for the installation, or for maintenance, so we have decided to again take the matter up immediately this coming week with the committee appointed by the association just mentioned, and I understand the same committee was reappointed by the Brick and Tile Association.

Now, as I say, we want to get at this thing immediately, and you do not think for a minute that we are not willing to put forth every possible effort, just as you desire us to do. But when we come before the legislature and present this matter, I want every man who is interested in the use of cement in the state of Iowa to make himself a committee of one to see or write to his member of the legislature and senator and tell them about the importance of the great work Iowa has taken up. There is only one way to get at this work and that is through this institution. I am not begging for the Iowa State College, not for a minute. We have a college at Grinnell that we are proud of, but that is not it. The Iowa State College is the only institution in the state that can take charge of this matter. They have been doing a great deal of work for which they have been receiving no renumeration whatever, and the state of Iowa is

amply able to make ten times as large an appropriation as we shall ask for.

It was reported yesterday that $300,000 was appropriated for a cement plant in our own state. Now I simply wanted to make this statement before I left, to exhort you to see your members of the legislature from your various counties and tell them of this work.

Mr. Humphrey: I personally do not want any one to feel for a minute that because the United States government is undertaking tests of this material on a larger scale, that it is unnecesary for local institutions to carry on such work. You can do work with your own materials that we perhaps cannot do, and we feel that the need for research is so great, the more we do the sooner we will solve the problem. Do not appoint committees to pass resolutions, but every one of you see the man who comes from your district, the man you know personally, and tell him what a great thing it is, and you will be surprised at the work you will do. You come here to the convention and listen to papers and go away with information received at a comparatively small cost, that means hundreds of dollars in any business, because it corrects errors that will hurt you. Now this is surely a good investment that will need no cash, but only a little personal talk.

I want you to receive kindly the suggestion that you pass resolutions endorsing the work at St. Louis. Perhaps you have not got in printed form as many results as you expect, but investigations of all kinds are slow, and you will get results from now on. Forty or more men at St. Louis are going to give you results, and it seems to me that it is but a small matter for you to pass resolutions; it may take a little more time to carry out Mr. Coutts' wish, but it certainly has my hearty endorsement. It will go a long way toward making the matter a success.

Pres. B.: I will refer this matter to the committee on resolutions which is to report this afternoon.

Convention adjourned until Friday P. M.

SIXTH SESSION

Friday Afternoon, 2 o'clock

The first paper was presented by Mr. R. R. Fish of Sandusky, Ohio, on Waterproof Compounds and Snow White Cement.

The president then announced the second paper by Mr. A. O. Anderson of Lake City, on

CEMENT POST DATA

The methods of manufacturing cement fence posts may be

divided into two classes, viz: the slush process and the dry or tamp process. In the former the cement mixture is made thin with much water and then poured into the molds; while in the latter, the mixture is comparatively dry so that it may be placed into the mold in layers and rammed. The first process necessitates a large number of molds, in fact, as many as the daily output of the plant, while in the dry process one mold can be used as often as it can be filled and tamped.

The relative merits of the two systems can be summed up by stating that, as the cement requires much water for its setting, the first process would seem to be most desirable and give best results; but the advocates of the dry tamp system say that a satisfactory product can be produced by watering the post after its removal from the mold. And besides this, the trouble of caring for a large number of molds is done away with. The one mold, which takes the place of a hundred in the slush system, can be made of iron which is much more durable than the ordinary wooden mold.

The dry tamp process may be subdivided into two classes depending on whether the post is moved from the machine or the machine from the post. The latter method seems to be the one most used. In this case the machine is so light that two men can easily move it. This also obviates handling the post until it is cured, which is very desirable, for a green fence post is a very fragile article.

Various styles of reinforcement are used, twisted wires, single wire, barbed wire, band iron, gas pipe and even old wagon tires. These should be placed as near the corners of the post as possible in order to secure the maximum strength of both the cement and reinforcement. Several methods of attaching the fence are in use, the most common being a double staple imbedded in the post and a tie-wire reaching around or perforating the post, so that a wire loop passed around the fence wire may be twisted tight by a nail at the opposite side of the post. In using metallic fasteners permanently imbedded in the post, care should be taken that they be well galvanized after making, so that they will be as durable as the post.

To secure information regarding the post industry, a list of questions was prepared and sent to all post manufacturers whose addresses could be obtained. The questions as well as a summary of the replies received will now be given.

1. What make of molds are you using?

As but one company making post machinery was inclined to furnish names of their customers, most of the replies to this question was "Elposco, Lake City, Iowa." However, "Petty-

john," "J. A. Mitchell," "National Automatic," "J. M. Keith" and "our own make" were some of the answers received.

2. How many molds have you?

The answers varied according to the process used, the dry tamp process requiring but one or two, while users of the slush method had from four to four hundred molds.

3. What reinforcement do you use?

Depends upon the make of molds used, the most common being a twisted pair of number 8 or number 11 galvanized steel wire. Other styles were, special punched bars, barbed wire, single strand wire, gas pipe, old iron rods, etc.

4. How do you fasten the fence to the post?

Holes through the post; tie-wires around it; special staples placed in pairs and making electrical connection between the fence and reinforcement, thus grounding the fence; and a special cast iron socket, built into the post, which receives a removable staple, were the most common devices used.

5. What is the cost of reinforcement and fastener per post?

The cost varied considerably, even in the same process and under the same patents, being from 4½ cents to 8 cents under the Elposco system. The Monarch reinforcement is listed at 3 cents per post while the fasteners are 4 cents, thus making the cost per post 7 cents.

6. What proportions of sand, gravel and cement do you use in the manufacture of posts?

This ranged from one part cement to two parts sand to one cement and six gravel. The usual reply was 'one to four.'

7. How do you cure your posts?

A few replies will be given as an illustration of the variety received. "In open air." "Water them for about a week." "Cover them with straw and keep wet for thirty days." "Keep in damp place out of sun and wind and thoroughly water for ten days." "Keep them wet."

8. How many hours and how many men are required to make 100 posts, including preparing the molds, mixing and placing the concrete into them, curing, yarding, etc., that is, to produce the post from raw materials to a marketable article?

This question also brought quite a variation in the answers from parties using the same process. The range for the slush process was from two men working ten hours to five men working ten hours and paid by the hundred. The usual reply was three men working ten hours. The dry tamped system gives about the same speed, the usual figures given in the catalogs being 50 to 150 posts per day for two men.

9. How many posts to each barrel of cement?

Of course this depends upon the mixture used, the average results secured were 28 to the barrel. The lowest figure was 23, while the highest 32.

10. What is your wholesale selling price per hundred?

Varied from $25.00 to $35.00. The average was $28.00.

11. About how many posts have you made?

The persons using home made molds had made a few, while those having a regular equipment had made from 100 to 5000.

12. What was your last year's output?

13. Was this an increase or decrease over the previous year and how much?

As a whole, the post business shows an increase.

14. How do the sales of cement posts compare with that of wooden posts in your vicinity?

Since the cement post industry is a new one, the wooden post still holds it own, but replies from parties who have been in the business for several years state that their sales compare favorably with that of wooden posts; in fact, a few seem to think that they are in the lead.

15. Are you satisfied with the post you place on the market? If not, can you suggest how it might be improved, or give your idea of an ideal post.

This question brought different replies, most of them stating that they were well satisfied, while others modified their statement by saying that "if well cured they are O.K." A few seemed to think that they could improve the post, while some had 'yet to see the fastener that suited them.'

16. Do you make a practice of testing or having tested the materials of which you make your post?

The majority do not test anything. Good results are obtained without and so they cannot see why the extra expense entailed by testing would be justified. The manufacture of cement has reached such a stage of perfection that the purchaser may be assured, when buying a known brand of cement, of satisfactory results.

17 and 18. Have you tested your post for strength and durability and if so, give results of such tests? How does your post fail when broken in the ground? That is, by crushing of the concrete or breaking of the reinforcement?

The first of these two questions brought but few answers, the majority of these being in the negative. The second gave some interesting results, some stating that the reinforcement broke first, while others said that the concrete crushed. A few stated that it was about a stand-off.

19. What percentage of the posts are lost, and in what

step of their manufacture does the greatest loss occur?

The loss seems to be very low and in most cases due to handling the post too soon after manufacture. One reply stated that about 5 per cent are lost.

20. From your own experience and observation would you advise others to take up cement post manufacture as a side line with the block business?

"Yes," was the usual answer. One negative reply was received but no reason given.

21. Give your opinion as to the future of the cement post industry and any suggestions you may have regarding testing of posts and other investigations you would like to have carried out.

All replies state that it is the coming post. A few replies are herewith given.

"It is the coming post, but any molds I have seen are too slow to handle, this is the main objection in manufacturing them."

"I expect the time will come when concrete posts will displace practically all wooden posts in farm and field fences."

"I think cement posts are the coming fence posts, but think that the farmer should make them himself at his own place, saving heavy hauling from a distance. I would not use other posts on my farm now."

"We think posts O K. and is the coming post. They are giving good satisfaction. When once sold to a farmer, they come back for more. Sell a good many farm rights."

This completes the list of questions. In conclusion will say that as the cement fence post is practically a new article, the greatest of care should be used in manufacturing and curing before placing it on the market. The post should be manufactured in a factory employing skilled laborers and equipped with efficient appliances for making and curing. Some persons seem to think that cement work can be done by anyone and at any time, but the number of defective sidewalks, disintegrated tile, and broken posts bear mute testimony to the contrary.

I shall be pleased at any time to learn the opinions and ideas of any post man regarding the industry and will try to answer such questions or give any information I can regarding cement posts or their manufacture.

DISCUSSION

Pres. B.: Are there any points to bring out, any questions to ask, or suggestions to offer?

Q. Suppose a case where these posts are set on very high ground and no moisture in the ground to speak of. If elec-

tricity strikes it, what effect will it have on these fence posts that have no ground connection. Will the electricity shatter them?

Mr. Anderson: It may shatter some of them, but we are not losing anything by having them grounded.

Pres. B.: The question is whether it might have been wise in such a case to run the wire further down?

Mr. A.: I suppose you can run it down as far as wanted. There would be no objection to running them further down.

Q. Doesn't any reinforcement in any style of post act on the same line?

Mr. A.: Reinforcement would protect that one post, but unless connected with the fence, would not be apt to protect the fence.

Mr. Kenney: What size are these posts?

Mr. A.: The usual size, I think is about 3 by 3 at the top, 7 feet long, tapering to six inches square at the bottom.

Mr. H. S. Williams: Electricity will not run from one post to the other, it will go to the ground. It will never hurt the stock at all. Where a post is properly made, using four cables, each a twisted pair of Number 9 wire, 3 by 3 inches at the top, and 4 by 4 at the bottom, it will bear a weight of 2000 pounds in the center if supported one foot from each end.

Pres. B.: Now I am sure that we have questions we would be very glad to ask President Humphrey. We can take up a half hour or so before going on with the program. I will ask that Mr. Humphrey come to the front, so we may all have the benefit of his advice.

Mr. Humphrey: One point I would like to call your attention to in the remarks of the gentleman who read the paper on cement posts. I think he said it was necessary to have the wires of the fence connected with the reinforcements of the posts?

Mr. Anderson: Well, that is one patent.

Mr. Humphrey: As a general proposition I would say it does not make any difference whether these are connected with reinforcements or not: it is often inconvenient. The object of putting reinforcements in a post is simply to strengthen the post. If a cow shoves against the concrete, it has not strength to resist that, so we put some form of metal in; so, whether the cow pushes, or the wire pulls it, there is enough metal to resist the strain.

Now, the other gentleman said that the electrical current did not jump at the cow when it hit the fence. The philosophy of the electrical current is that it will go right along the wire. The current will pass in the direction of least resistance, whether

this be along the wire, into the ground, or to the animal. If the animal is in the way, is directly along the wire, then the current will go to the cow. If the wire is grounded at each post, then the cow standing right near the wire would not receive the benefit of the shock, but the current will go down to the ground.

Q. How about cement being a conductor of electricity?

Mr. H.: Cement is a non-conductor.

Pres. B.: In steam curing, about how high a pressure has been used?

Mr. H.: The question of pressure is the whole thing. Steam for instance at 40 or 50 lbs. may be very damp, or 60 or 80 lbs. be very dry, and it matters not what the pressure be. The more pressure, the more moisture there must be in order to keep it damp. It must be sufficiently saturated that, instead of taking the moisture, it will give up moisture.

Pres. B.: The temperature, say running about 90 to 125 or 50, is not injurious to the cement?

Mr. H.: When you get up to those high temperatures you may have it hot enough to drive the moisture off. Generally speaking, you don't want to get it much above 100 degrees.

Q. Is the common exhaust steam dry or damp?

Mr. H.: As a rule, it would be wet.

Q. Suppose you wanted to make a storage tank for a farm, storing water, say 20,000 gallons or so, and you wanted to store it above ground four or five feet. With our temperatures as we find them up and down, how many air spaces, or what would you do to keep the water from freezing?

Mr. H.: You want to know how thick to make the concrete?

Q. No, how many air spaces, so the water would not freeze, provided you did not pump for three or four days.

Mr. H.: It might be three or four inches thick, but you would have to reinforce it with steel, and the probability is you would have these walls four or five inches thick. Concrete is a non-conductor of heat and is likewise a non-conductor of cold. It is a very poor conductor of heat or cold.

Pres. B.: The question came up this morning, "What is quicksand," and it was not answered very satisfactorily.

Mr. H.: Well, quicksand is a material difficult to define. Take sand and put it in water sufficient to saturate it, then take it out, and the amount of water will vary with the nature of the grain. In quicksand, as I understand it, the coating of water is quite heavy in proportion to the size of the grain. It is all

the same, all fine, and will slip all around; has no power of resistance. If you mix a substance with it, the substance will go right down. I think it is that coating of water that gives the sand the name quicksand. I cannot throw much light on it.

Q. Is not quicksand a condition; is it not very fine sand in a state of saturation?

Mr. H.: It might be, yet you can take some very fine sand and saturate it and you would not have quicksand.

R. Yet what we call quicksand, if you dry it out, is not quicksand when the water is removed.

Q. What is the form of quicksand?

A. All round particles, smooth.

Mr. H.: I think it is the film of water that coats it. There is no contact between the granules. I understand that the film of water prevents contact and makes it slip around.

Pres. B.: The question came up the other night about using very fine sand with cement to make concrete. One gentleman had some very fine sand on his farm, and wanted to know whether he could use it to advantage with cement.

Mr. H.: When you have extremely fine sand it is difficult to mix it with cement, so as to get good contact; furthermore, the amount of air included in that mortar is so great that it is difficult for it to get out. You get density in mortar by the amount of work you put on it. The success in getting the density will depend upon the amount of work you put on it, the more elbow grease you apply; the finer the sand the more difficulty you will have in getting the density. It is generally true that the amount of voids in fine sand are much greater than in coarse mixtures.

Q. I am using a continuous mixer for concrete. The cement and sand enter together at one end, there being a fan inside that mixes them up. Now where had the water better be applied to the mixture? Should it be applied just as it comes out, or one foot in, or two feet in?

Mr. H.: You had best run it through your mixer dry, and then wet it, but this is hard because you have only one mixer. It is better, though, to mix it dry before you put in the water. I confess myself I am not very partial to a continuous mixer. I would not want to advise you where to add your water, but will say that the materials should be mixed dry and then add the water. The whole secret of success in concrete mortar is the mixing. The more you mix it the better it is going to be. On the other hand, it is possible to mix the stuff too much. Of course there is a limit to everything. You can mix cement so long that it will set while you are mixing it.

I do not think you ought to mix concrete more than fifteen or twenty minutes.

Q. Is it all right to use frozen sand, froze so hard that it is apparently dry, but when you get into the building and warm air strikes it, it is wet. Is it all right to put that in before it thaws out?

Mr. H.: Well, as long as the concrete or mortar has to set in a normal atmosphere, I suppose you could do that, but generally speaking, the best results are obtained by drying your sand; and, if the sand be frozen, taking the frost out before you attempt to mix it with the cement. I would not recommend using the frozen sand except under extreme conditions, when you could not avoid it.

Q. How long can concrete lie mixed before you put it in the machine?

Mr. H.: If it is in a very wet, sloppy condition, one or two hours without detriment, but all that time the process of hydration of that cement is going on. If it is quick setting, then the time you can keep it may not be even a half hour, and probably inside of ten or fifteen minutes you might see signs of setting. I have seen signs of setting inside of five or six minutes.

Q. What do you consider will stand fire best, slush block or the dry tamp?

Mr. H.: The philosopsy of fire is simply this: Where building walls are submitted to the action of the same heat that you saw in that picture, the disintegration of the mass would be produced by the driving off of the water. The application of water simply washes away the loose outer material, which then has no strength itself. Now, if a block be porous, as soon as the water hits it and plays on it for any time, it will go into the mass. The penetration of heat will decrease as the density increases, so there will be less crumbling by heat in the denser block, because of the less dehydration or driving off of moisture. Concrete will stand fire. The tests at San Francisco showed that it offered as good resistance, and in most cases far better resistance than other building materials. 1700 degrees F. is as high a temperature as you are ever apt to get. It would be an extremely rare condition where that degree of heat would continue an hour and a half and where firemen would go near enough to put on a stream of water at 50 pounds pressure at 20 feet. The fire insurance men insist that these are the conditions that we have to meet, so we are attempting to do that.

Q. How would granite do?

A. Granite would go all to pieces with the application of water.

Q. How would sandstone be?

A. Sandstone is a little better.

Q. How would hard brick be, as compared with cement, in fire resisting qualities?

Mr. H.: Of course brick can be burned hard, as you know, so hard that it gets brittle in high temperatures. When you put water on them they go all to pieces.

Q. Were the webs of these blocks that you tested cracked?

Mr. H.: In some cases there was a crack right down the center of the web. In other cases the web passed through all right.

Q. What about the percent of moisture in brick?

Mr. H.: That depends on the atmospheric conditions. Brick will absorb from 6 to 20 per cent of water. On an average about 6 or 8 per cent of water.

Prof. Beyer: Mr. Chairman, I want to return to quicksand for a minute. It has occurred to me that as long as this has been coming up every year, and answers seem to differ somewhat, that it would be a good plan for different people to send us in five or ten pound samples and let us find out what it is. Perhaps by next year we can tell you what quicksand really is physically. I will be glad to do the work, or see that it is done, if you will furnish the quicksand. A cigar box full will be a sufficient sample.

Pres. Bingham: Mr. McNabb of Emmettsburg, since coming here, has been making a few tests of tile of different kinds, and we will have his report now.

Mr. G. D. McNabb: My position in this convention is more in the nature of a spy than as one of the cement workers. During the season of 1907 in the county in which I have charge of the drainage work, I will have to pass on the quality of something like 40 to 60,000 cement tile. I have been trying to find out whether cement tile will do the work and stand the conditions under which the people say they will have to be put. This morning I went up town to the lumber yard, picked out some samples of clay tile, and I want to say for the benefit of you cement people that I don't believe it would be possible to pick out a better tile than this. We took them to the testing room and with the assistance of two students, broke them.

Now here is a cement tile to start with, two months old, which stood a pressure of 980 lbs., and, while it is cracked, it is still a good tile. I would not object to it being laid in the ditch to do the work to the end of time.

Here is a four-inch clay tile that you see is remarkably well burned. That tile stood a pressure of 1015 lbs., and it was all in pieces when we took it out; 35 pounds difference between the cement and clay.

Here is a four-inch clay tile that stood a test of 1650 pounds; here is a six-inch cement tile, 4 to 1 mixture, which stood 795 pounds and cracked. Then here is a six-inch tile of the clay that stood 830 pounds, and the six-inch cement, two months old, stood 795 pounds; 35 pounds difference.

Q. How does the thickness of the shell compare?

Mr. McNabb: This clay tile seems to be about $\frac{1}{16}$ of an inch thicker.

Q. Do you know anything about the relative cost of these tile?

Mr. McNabb: They retail about the same price; cement people are meeting the clay price.

Q. Is it not the tendency of these clay tile, after they have lying in the ground for some years, to scale off and disintegrate?

Mr. McNabb: Only at the end of the ditch where they have been exposed to the air and frost. Ever since I can remember I have been around tile and tile ditches, hauling tile, filling ditches, and looking after drainage work, and I have seen a great many varieties of clay tile put in the ground. I have seen them after they have been in the ground from six to twenty years, and have never seen a clay tile tha was once gotten into the ground and kept covered that ever went to pieces; there have been some failures, however. I have examined tile that I hauled myself, twenty years ago, and they are all right.

Q. Have you ever dug up any of these tile?

Mr. McNabb: Yes, I have dug up quite a number. There are clay tile in Iowa that have not been properly burned, and will go to pieces in the ground. I have not seen these myself, I have seen the man who did see them. The same tile properly burned are all right. A great many clay tile will lay out all winter without damage, but you have to be very careful with them. That will be a benefit to you cement people. Farmers do not have anything to do in the winter, and can haul their cement tile without risk.

Pres. B.: I am sorry to interrupt this discussion, but we have our business session before us. The first is the report of Secretary Williams.

SECRETARY'S REPORT

The following brief statement will be sufficient to place before you the work of the Association during the past year:

MEMBERSHIP.

The recorded membership of the 1906 meeting was essentially 100 persons. A considerable number registered who did not become members, and still others attended the convention whose names do not appear on our lists.

EXHIBITS.

Seventeen firms manufacturing cement using machinery, engaged space for exhibit; also three of the leading Portland cement companies.

PROGRAM.

Thirteen formal papers were read at the 1906 convention.

COMMITTEES.

Committees were appointed at the 1905 meeting to draft standard specifications for sidewalks. This committee presented a set of specifications last year which are to be found in the proceedings of that meeting.

At the 1906 convention a committee was appointed to formulate standard specifications for hollow concrete blocks, consisting of O. U. Miracle, Geo. Gabler and Wm. King. The report of this committee was adopted, and the specifications drafted were printed in last year's proceedings.

RESOLUTIONS.

Resolutions were passed by the association earnestly approving and favoring the continuance of the investigation of cement mortars and concretes at the U. S. Geol. Survey Testing Plant at St. Louis. Also petitioning congress to provide for carrying on this work on a much larger scale.

Resolutions were also adopted favoring the establishment of school of ceramics at the Iowa State College. The president of the Association was empowered to appoint a committee of three to lay the importance of this matter before our state senators and representatives. President Bingham appointed Messrs. R. G. Coutts of Grinnell; G. H. Carlon, Oskaloosa; J. B. Marsh of Des Moines on this committee.

The favorable outcome of the enterprises referred to in both of the above resolutions has been fully reported to you earlier in this convention.

CONTRIBUTIONS.

Several of the companies which have exhibits here have contributed generously towards the support of the association.

To these this opportunity is taken to express publicly as an organization, our best thanks. Also to emphasize this fact to you as cement users and to call your attention to the published list of contributors on your programs.

FINANCES.

During 1906, 102 membership fees were received. Membership dues and exhibit fees were the sources of revenue to the Association, and the income from these a little more than balanced the expenditures.

PROCEEDINGS.

Arrangements have been made this year to send the proceedings of the convention to all paid up members, whether such members are in actual attendance or not. The advantage in this is evident, and the value of having these transactions to refer to will certainly appeal to everyone. To those who are not members, the proceedings will cost fifty cents.

Pres. B.: What shall we do with the Secretary's report.

Moved and seconded that the report of the Secretary be accepted. Motion carried.

Pres. B.: Next is the report of the committees. The committee on legislation reported this morning. We will have the report of the committee on resolutions.

The chairman of the committee, Mr. J. N. Muncey, presented the following report:

Resolved, That we, the members of the Iowa Cement Users' Association, extend our sincere thanks and appreciation to the faculty and management of the Iowa State College for the kind and courteous treatment which we have received during this session.

Resolved, Further, we, by a rising vote, express to the President, L. L. Bingham, and to the Secretary, I. A. Williams, our hearty approval of the unbiased attention and liberties extended to the various competitive interests here represented, and especially to the excellent and carefully prepared program of such a general nature as to permit of wide discussion on all timely subjects connected with the cement industry.

Resolved, Further, that we regret, owing to some unfortunate circumstance, there was not a better display of cement machinery, inasmuch as the management of the college had gratuitously extended proper room for such exhibits, and to the fact of the large number of prospective purchasers.

Resolved, Further, that we, the cement users of Iowa and other states here represented, are not in sympathy with any manufacturers of cement in Iowa or the United States who are promoting or in any way associating themselves with the Lumber Trust, with a primary view of discrimination against contractors and users.

Whereas, the cement industry is developing most rapidly, especially in the state of Iowa, and

Whereas, there is a great need for information on all matters relating to the proper uses of cement, and,

Whereas, the Association recognizes the great good now being done by the Iowa State College in this direction,

Be it resolved, that we, the Iowa Association of Cement Users, in convention assembled at Ames, Iowa, do hereby petition the state legislature to appropriate a sufficient sum of money for carrying on the above mentioned work, and

Be it further resolved, that each member constitute himself a committee of one for securing such an appropriation.

Whereas, the U. S. Geological Survey is carrying on investigations of Fuels and Structural Materials which are of great importance to the general public, and

Whereas, the results of the investigations of cement mortars and concrete are of inestimable value to all users of cement,

Be it resolved, that we, the Iowa Association of Cement Users in convention assembled at Ames, Iowa, January 23-25, 1907, do hereby most heartily endorse this work and petition the congress of the United States to continue the appropriation for this work so that it may be completed and

Be it further resolved that the secretary of the Association be hereby instructed to transmit a copy of these resolutions to the president of the United States senate, the speaker of the house of representatives, and to each member of congress from the state of Iowa. (Signed)

D. P. Faus,
J. N. Muncey,
Wm. Stuart.

Each section of the resolutions was acted upon separately and the entire report adopted by the Association.

Pres. B.: Next is the report of the committee on nominations.

Prof. Beyer: Mr. Chairman, your committee reports the following: For president, Mr. George H. Carlon, of Oskaloosa; for first vice president, Mr. D. P. Faus, of Waterloo; for second vice president, Mr. James Maine, of Des Moines; for treasurer,

Mr. Geo. R. Ross, of Grinnell. and for secretary, Mr. Ira A. Williams, of Ames.

(Signed)
E. KENNEY, Creston.
H. C. SHADBOLT, Emmettsburg.
S. W. BEYER, Ames.
Committee on Nominations.

Moved and seconded that the report of the committee on nominations be adopted, and the secretary be instructed to cast the unanimous ballot of those present for these several gentlemen. Carried.

Pres. B.: I have the honor to present to you the incoming president, Mr. Geo. H. Carlon of Oskaloosa.

Mr. Carlon: I want to thank you for this honor, coming from this honorable body of men. Ever since this Association has been organized it has been my aim to do what I could for its advancement and welfare. I stand ready and willing to do whatever I can for each and every member of the Association, and I believe the first thing I will do will be to appoint every member of the Association a committee of one to come here next year with a paper, or short speech, say five minutes. I would rather have a hundred five minute speeches from practical men than a dozen half-hour speeches. I thank you again for your kindness.

Pres. B.: Let us have a five minute speech to begin with.

Pres. Carlon: I have only about seven minutes to make my train. If there is nothing further to come before the convention, we may consider ourselves adjourned.

LIST OF EXHIBITORS.

Marquette Cement Manufacturing Company, Chicago, Ill. Represented by R. B. Dickinson, Chicago; A. A. Sheneberger, Cedar Rapids.

Atlas Portland Cement Company, New York City. Represented by F. C. Bailey, New York; Jno. G. Evans, Chicago.

Universal Portland Cement Company, Chicago, Ill. Represented by E. A. Coates, Chicago.

Ballou Manufacturing Company, Belding, Michigan. Represented by T. C. Jennings.

Expanded Metal and Corrugated Bar Co., Frisco Bldg., St. Louis, Mo. Represented by W. C. Berry.

Hiram Routt, Dallas Center, Iowa.

Miracle Pressed Stone Company, Minneapolis, Minn.

Sandusky Portland Cement Company, Sandusky, Ohio. Represented by R. R. Fish, Sandusky.

Names of those in attendance who registered, arranged by counties.

AUDUBON COUNTY

T. W. Staley, Audubon.
T. G. Jensen, Kimballton.
Geo. Henningsen, Kimballton.
Bert Eaton, Audubon.
Viggo Rasmussen, Brayton.
A. T. Rasmussen, Brayton.

BENTON COUNTY

Wm. Bossen, Van Horne.
S. V. Everett, Blairstown.
W. H. Thompson, Vinton.

BLACK HAWK COUNTY

E. J. Buchan, La Porte City.
D. P. Faus, Waterloo.
W. H. Shirey, Waterloo.
J. H. Stewart, Waterloo.
L. L. Tippey, Waterloo.
F. J. Pfiffner, Waterloo.
J. H. Anderson, La Porte City.

BOONE COUNTY

A. H. McGregor, Berkley.
Richard Clabby, Ogden.
E. H. Samuelson, Boone.
A. M. Shaeffer, Boone.
L. F. Fehleisen, Boone.
M. H. Rossacker, Ogden.
E. S. Thorngren, Boxholm
Axel Western, Boxholm,

BUCHANAN COUNTY

J. N. Muncey, Jesup.

BUENA VISTA COUNTY

W. A. Barnes, Storm Lake.
J. K. Salveson, Sioux Rapids.

CALHOUN COUNTY

W. L. Skinner, Farnhamville.
Earl Skinner, Farnhamville.

CARROLL COUNTY

O. W. Carpenter, Coon Rapids.

CASS COUNTY

Milo H. Cook, Griswold.

CEDAR COUNTY

R. Brewer, Lowden.
C. S. Hollingsworth, W. Branch.

CERRO GORDO COUNTY

Geo. Gabler, Mason City.

CHEROKEE COUNTY

T. D. Campbell, Cherokee.

CLAY COUNTY

Axel Ruthven, Ruthven.

CLAYTON COUNTY

M. M. Mellen, Edgewood.

CLINTON COUNTY

C. B. Roman, Camanche.

CRAWFORD COUNTY

J. B. Truesdale, West Side.

DALLAS COUNTY

Hiram Routt, Dallas Center.

DECATUR COUNTY

Geo. H. Derry, Lamoni.

DELAWARE COUNTY

Philip French, Ryan.

DES MOINES COUNTY

Chris Vestesen, W. Burlington.

DICKINSON COUNTY

J. M. Johnson, Spirit Lake.

EMMET COUNTY

W. M. Stewart, Armstrong.
L. L. Bingham, Estherville.

FRANKLIN COUNTY.

G. E. Sargent, Hampton.
M. Holub, Hampton.
C. S. Jernegan, Hampton.

GREENE COUNTY

F. D. Milligan, Jefferson.
T. A. Mugan, Jefferson.
W. S. Allen, Scranton.
P. L. Cockerell, Jefferson.
D. E. Donovan, Jefferson.
I. H. Waller, Grand Junction.
Richard Wiltse, Grand Junct.
Allen Glenn, Scranton.

GRUNDY COUNTY

R. E. Lynn, Grundy Center.
E. J. Akin, Grundy Center.
T. Johnson, Grundy Center.

GUTHRIE COUNTY

F. E. Butler, Jamaica.
A. A. Smith, Jamaica.

HAMILTON COUNTY

Geo. W. Wareham, Jewell.
A. H. Alexander, Jewell.

HARDIN COUNTY

B. F. Wright, Radcliffe.
H. C. Chopin, Union.

IOWA COUNTY

H. Harrington, No. English.

JASPER COUNTY

Warder Mershon, Newton.
C. S. Mershon, Newton.

JACKSON COUNTY

R. E. Walker, Sabula.

KOSSUTH COUNTY

A. J. Lilly, Algona.
Henry Lilly, Algona.
J. H. Welp, Bancroft.

LINN COUNTY

Thos. J. French, Coggan.
J. C. Fulkerson, Cedar Rapids.
J. F. Neubauer, Cedar Rapids.
G. W. Pichner, Cedar Rapids.

MAHASKA COUNTY

Geo. Wiswell, New Sharon.
McCutcheon & Strahan Cement Block Co., New Sharon.
Geo. H. Carlon, Oskaloosa.

MARION COUNTY

Leopold Little, Knoxville.
S. C. Johnston, Knoxville.

MARSHALL COUNTY

E. E. Girton, Rhodes.
E. H. Schilling, State Center.
A. O. Keen, LeGrande.
C. A. Buchwald, Marshalltown.
R. H. Sutherland, Gilman.
R. C. Muller, Gilman.

MONONA COUNTY

K. A. Pullen, Onawa.

MUSCATINE COUNTY

C. H. Van Epps, Wilton.
J. R. Corbett, Lone Tree.

O'BRIEN COUNTY

Ed. Clift, Sutherland.
B. H. Heckert, Sutherland.
J. S. Webster, Hartley.

OSCEOLA COUNTY

Geo. F. Sokol, Sibley.
W. T. Suter, Sibley.

PALO ALTO COUNTY

S. H. Bauck, Emmettsburg.
H. C. Shadbolt, Emmettsburg.
G. D. McNabb, Emmettsburg.

PLYMOUTH COUNTY

B. Kramer, LeMars.

POCAHONTAS COUNTY

J. O. Burington, Pocahontas.
M. Butterton, Pocahontas.
E. O. Donnell, Fonda.

POLK COUNTY

Jas. H. Maine, Des Moines.
J. B. Marsh, Des Moines.
Frank Perkins, Des Moines.
H. E. Shafer, Grimes.
H. R. Reed, Grimes.
W. A. Lawrence, Des Moines.
Mrs. W. O. Sloan, Des Moines.
Geo. A. Jewett, Des Moines.
W. O. Sloan, Des Moines.
H. H. Flanagan, Des Moines.
H. H. Reynolds, Des Moines.
Mrs. H. H. Reynolds, D. Moines.

POTTAWATTAMIE COUNTY

A. T. Barnes, Neola.

POWESHIEK COUNTY

Geo. R. Ross, Grinnell.
R. G. Coutts, Grinnell.
C. W. Carter, Grinnell.
H. H. Connell, Deep River.
Mayo Harris, Grinnell.

SAC COUNTY

L. Christensen, Grant City.

C. M. Jensen, Grant City.
C. C. Wetzstein, Early.
G. H. Wetzstein, Early.

SCOTT COUNTY

J. N. Reimers, Davenport.

SIOUX COUNTY

H. E. Rounds, Rock Valley.
M. I. Quinn, Rock Valley.

STORY COUNTY

Jas. H. Larson, Roland.
J. H. Larson, Slater.
Jas. McCoy, Colo.
B. F. F. Nickerson, Ames.
E. B. Howard, Ames.
F. W. Clausing, Ames.
Geo. A. Barhite, Ames.
N. Tjernagel, Story City.
H. R. Bell, Gilbert.
Ed. Binder, Colo.
Jno. M. Wells, Nevada.
Victor Kulon, Maxwell.
F. B. Parsons, Clemons.
W. C. Reynolds, Gilbert.
G. F. Davis, Ames.
W. F. Bales, Colo.

TAMA COUNTY

B. Brewer, Dysart.
Jno. A. Berner, Gladbrook.
C. G. Kaiser, Dysart.

UNION COUNTY

E. Kenney, Creston.
L. Kenney, Creston.

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J. B. Allen, Ottumwa.

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Iowa Hydraulic Stone Co., Ft. Dodge.

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L. S. Johnson, Sioux City.

WRIGHT COUNTY

M. H. Hanson, Belmond.
Geo. Schumacher, Clarion.
Jas. L. Shearer, Goldfield.
LeRoy Holding, Eagle Grove.
M. H. Ireland, Eagle Grove.
J. M. Overbaugh, Clarion.

J. C. Jennings, Ballou Mfg. Co., Belding, Mich.
Geo. F. Keil, Sherburn, Minn.
D. G. Keith, Ceylon, Minn.
Frank Little, Ceylon, Minn.
E. M. Newton, Rock Products, Louisville, Ky.
Geo. McAllister, Glencoe, Minn.
Albert Anderson, St. James, Minn.
F. C. Bailey, New York City.
W. C. Berry, Exp. Metal & Corrugated Bar Co., St. Louis.
Geo. C. Currie, Boissevain, Manitoba, Canada.
E. A. Coates, Universal Portland Cement Co., Chicago.
P. J. Collins, Omaha, Neb.
R. B. Dickinson, Marquette Portland Cement Co., Chicago.
Jno. G. Evans, Atlas Portland Cement Co., Chicago.
R. R. Fish, Sandusky Portland Cement Co., Sandusky, Ohio.
Wm. Seafert, Cement & Eng. News, Chicago.
Chas. Worthley, Monterey, Minn.
R. S. Warner, South Dakota.

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EDITORS

G. W. BISSELL,	*Professor of Mechanical Engineering*
A. MARSTON,	*Professor of Civil Engineering*
L. B. SPINNEY,	*Professor of Electrical Engineering*
S. W. BEYER,	*Professor of Mining Engineering*

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Announcement

At the end of the present College year Prof. G. W. Bissell will give up his position at the Iowa State College to assume that of Professor of Mechanical Engineering and Dean of Engineering at Michigan Agricultutal College.

The management of the Iowa Engineer will devolve upon Prof. I. A. Williams after the May number and it is hoped that the usefulness of the publication will be extended more and more each year untill it shall be recognized as the technical organ of the college, of the industrial interests of the state and of the engineering alumni of the college.

THE BUSINESS SIDE OF ENGINEERING

S. T. HEDGES.*

I am asked by Professor Marston to write a paper on this subject. He is kind enough to say that it will be of great value to the engineering students; and, while his sentiments are certainly appreciated, can only say that if the results of my experience and observation are of any assistance, whatever, I shall feel more than repaid.

Most students on entering college, do so with but very little preconceived idea as to their future work in life. The course of study which they select is usually the result of fancy, or the advice of some friend, who, possibly, may have taken the same course.

Many students take the engineering course who would have made better farmers, and, vice versa. One thing, how-

*Class '86, Iowa State College. President Puget Sound Bridge and Dredging Co., Seattle, Wash.

ever, is certain—the effort and study necessary to receive a degree, in any of the courses is of great value. Along this line I wish to call attention to one phase of college life that was neglected during the time which I spent there—this is the social life. A young man who has seen so little of social life as to be ill at ease in company, or is too diffident to clearly express himself in public, no matter how bright, or how much knowledge he may possess, is at a great disadvantage in this world. More social life at college would be pleasant and at the same time just as profitable as any of the hours spent in studies and recitations.

During college life, about all that can be obtained is the theory of engineering, with a smattering of practice; possibly, enough practice to enable the young engineer to apply the theory later in life.

I would impress on every engineering student that he be very thorough in his mathematics. Many times in practice he will be able to use mathematics to solve problems he never dreamed of; in other words, the average student is prone to consider mathematical problems as simple abstract propositions of no practical value. If his instructor calls attention to practical applications, he is fortunate in having an experienced instructor. On the other hand, if mathematics are poorly understood at college, there is little time in practice to study up on theory, and as a result he falls far short of his possibilities as an engineer.

There are at the present time, many good reference books on almost any engineering subject; and the engineer who has been diligent in theory, during his student life, is easily able to make his own, any subject which he may be investigating.

As to the business side of engineering:

It is a well understood principle, that to be successful in any business, one must understand that business, thoroughly, not only in a general way, but in detail. One of the most successful contracting engineers it was ever my pleasure to know, not only understood every detail of his own machine, but, also, more about the machines sold by his competitors than most of their agents.

The question, therefore, arises how best to become acquainted with any particular line of business. My answer is,

begin at the bottom and learn the business. If in the manufacturing business, go in the shop and help build the machines, and out in the field and help erect them One month's work in actually building any manufactured article, will give the young engineer a better idea of its details than a year in looking at drawings or pictures. By spending a year or two in this manner, the young engineer will have a fair knowledge of the manufacture of most articles.

With this knowledge of manufacturing and field work, the engineer has learned to see things as they are and is ready to begin work in the drafting room—that is detailing work and putting it on paper, that has been designed by others. It may seem of little value when in college, to spend time in lettering. I wish to say that every student, upon leaving college, should be able to make at least one style of lettering, free hand, rapidly and neatly.

With the previous knowledge of how a manufactured article is actually made and how it looks, work in the drafting room should be easy. Drafting is usually done under a head draftsman who checks all mistakes, so that the young engineer should soon become accurate.

After a time spent in the drafting room, the young engineer is ready for designing and estimating. We might define the science of engineering as accomplishing a given result, at the least possible cost. The engineer applies the theory and knowledge he has already gained to design other structures. He uses theory to compute the stresses, and his knowledge of shop and field work to determine the least cost of construction.

It is assumed that up to the present time the engineer's knowledge of cost is only relative, that his experience has only taught him what details, etc., can be economically manufactured and assembled. If, however, he be of an enquiring turn of mind, he has without doubt made many calculations and notes as to the actual cost of construction under different conditions, and has read many good reference books giving the cost of construction, as done by others.

Thus far, the engineer's experience has been along purely engineering lines, and it is a milestone that many engineers never pass—often times from choice.

We would define business engineering as the science of

securing work of an engineering nature, at profitable prices, and the execution, economically, after securing the same. The one presupposes the ability to make an intelligent estimate of cost, and the other, to execute work at below this estimate. The first has to do with the contracting, and the second, with the administration engineer.

The contracting engineer to be successful, must combine the ability, knowledge and experience of the technical engineer, with the qualities of the salesman. These two qualifications are usually found wanting in the same person, and many times the duties are divided—the engineer doing only the engineering part, and the salesman, with a smattering of engineering knowledge, using plans and specifiations prepared by the engineer to present to the purchaser. If, however, as often happens, there is some engineering change made, a salesman only, loses the business to an able contracting engineer, who does all the business within himself, and does not have to rely on an engineer, often not present. The contracting engineer, also, has another great advantage over the salesman, only; when tendering on work he is able to explain more fully his design, and answer more intelligently the questions of customers, than his salesman competitor.

Allow me, also, to suggest that the social training, etc., spoken of previously, are of great value to the contracting engineer. The little qualities that can hardly be named, that go to make up the polished gentleman, lend wonderful assistance when meeting strangers.

Granted that business has been secured at a fair estimate and profit, it is the effort of the administration engineer which finally determines the actual cost of work, and whether the balance is on the right side of the ledger.

He must organize the business so that it is executed systematically and intelligently. He must not delude himself into the belief that work is being done at a lower cost than it really is. In other words, realize that the cost of work is not alone the actual amount of money spent, but that to this must be added contracting expense, cost of repairs, a percentage of the first cost of plant, interest on investment, depreciation, insurance and administration.

With the total cost of work carefully tabulated, he ad-

vises the contracting engineer as to the actual cost of work executed, and thereby aids his judgment as to the cost of future work of similar character tendered upon.

The administration engineer who enjoys the greatest success, must also be a financier, must be in touch with the financial condition of the country in which he is operating and its prospects for the future, the amount of business in his particular line and what his competitors are doing. Many a contracting firm has made itself wealthy by allowing competitors to contract their entire output at low prices, and then secure all the business it could do at a good margin; this, by a knowledge of the situation.

He must also be able to judge the credit of purchasers and be certain that they are able to pay for work contracted for, any other course is sure to lead to a receiver sooner or later.

As a matter of statistics, it may be stated that 50 per cent of general contracts in the United States are secured below cost, 25 per cent at practically cost, leaving only 25 per cent having a reasonable margin of profit.

In conclusion:

The competent technical engineer is certain of a lucrative position or practice at all times.

The competent contracting engineer is scarcer and harder to obtain, and, by the inevitable law of supply and demand, his services usually command higher prices.

The man who is a successful technical and contracting engineer, and, in addition, is capable of administering a contracting or manufacturing business, as well, is either doing a successful business himself, or running a business for others at, practically, his own terms.

CHART FOR CARPENTER SEPARATING CALORIMETER

G. W. BISSELL.

The separator, extensively used in power station practice for removing entrained water from live steam—or grease from exhaust steam, has, when properly designed, an efficiency practically equal to unity, as was demonstrated by

Messrs. Brill and Meeker in 1891 at Cornell University. Prof. R. C. Carpenter, in charge of experimental engineering at the same institution, acting upon the suggesting presented by the results of the experiments of Brill and Meeker, devised the Carpenter Separating Calorimeter for measuring the moisture in steam and designed the present form of the instrument as manufactured and sold by Shaeffer and Budenburg, New York.

The sample of steam is collected in the same way as with other forms of calorimeter. The instrument is a small separator for the sample which flows through it into the open air. The moisture is precipitated and collected and may be drawn off at intervals and its amount measured by volume or weight.

Extensive experiment has demonstrated its accuracy. In the marketed form of the instrument, the collecting chamber for the moisture is provided with a graduated water glass and scale with which and a stop-watch the rate of the precipitation of the moisture can be readily determined. The scale is graduated to 100ths of a pound and it is usually convenient to read the time for collecting 1-10th pound.

The flow of steam through the instrument is determined by a standard orifice, a pressure gauge and Napier's rule.

A steam jacket and lagging together reduce the radiation loss to a negligible quantity, especially in view of the uncertainty of the representative character of the sample whose moisture is sought.

The mathematical theory of the instrument is as follows:

Let w=weight of moisture precipitated in pounds per hour.

t=time in minutes required to precipitate 1-10 lb.

$$\text{Then } w=\frac{6}{t}$$

Let W=weight of steam issuing from the orifice of the instrument in lbs. per hour.

P=absolute steam pressure in lbs. per sq. in. which forces the steam through the orifice.

A=area of the orifice in sq. in.

Then $W = \frac{3600 \times P \times A}{70}$

Let m = percentage of moisture

Then, evidently, neglecting radiation,

$$\frac{m}{100} = \frac{w}{W + w}$$

The usual diameter of the orifice is 1-16th inch and its form is circular. For this case

$A = 0.00307$ sq. in.

Then

$$W = \frac{3600 \times 0.00307 \times P}{70}$$

$$= 0.158 \times P$$

Then also

$$\frac{m}{100} = \frac{\frac{6}{t}}{0.158 \times P + \frac{6}{t}}$$

$$= \frac{6}{0.158 \times P \times t + 6}$$

This formula gives a ready means of calculating the percentage of moisture.

By transposition, we have

$$Pt = 38 \frac{100 - m}{m}$$

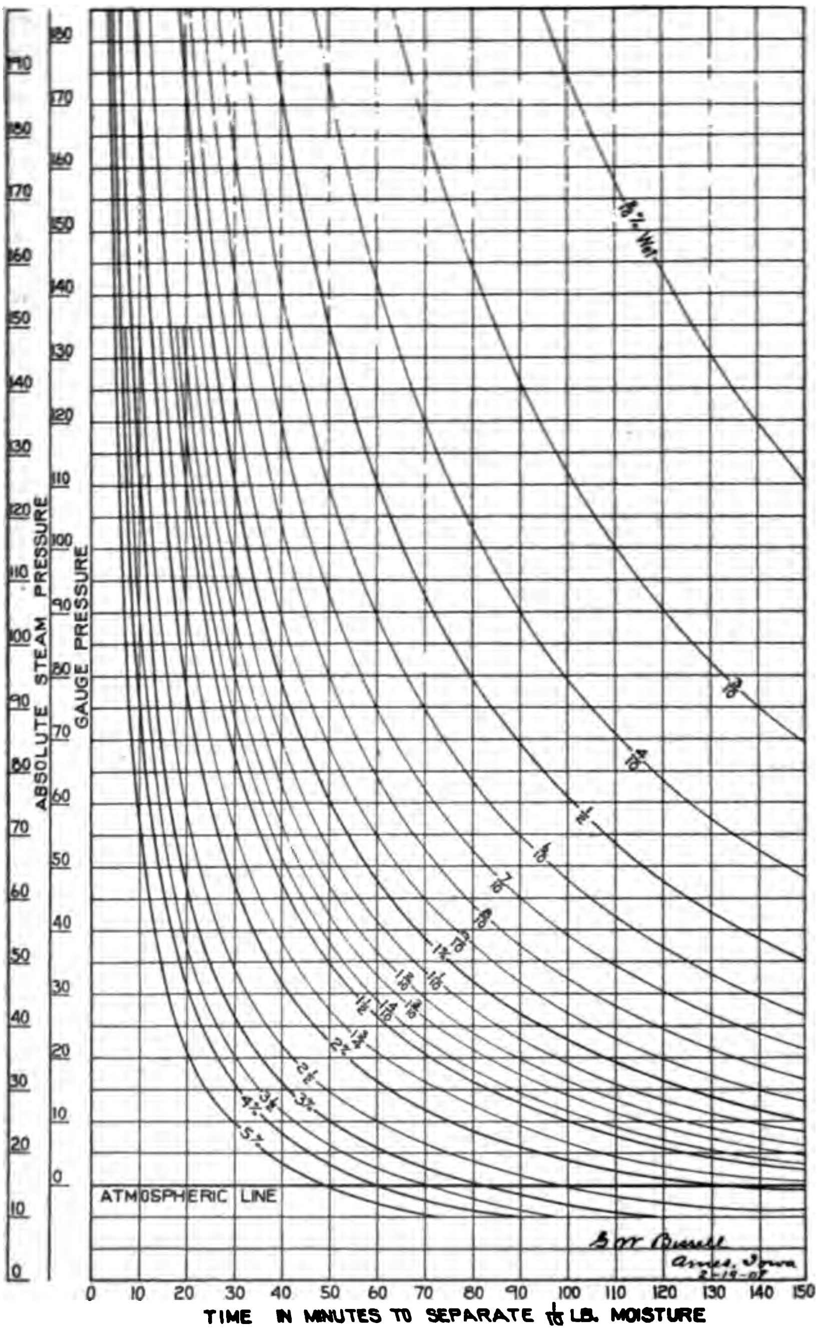
If *m* be constant the last form is the equaton of an equilateral hyperbola with *P* and *t* as co-ordinates.

Subjoined is a chart obtained by plotting the relation of P and t for each of several separately assumed constant values of m.

Thus m=constant=1 per cent of moisture.

Assume P=	20, then t=	188.10
	40	94.05
	60	62.70
	80	47.02
	100	37.62

Chart for Carpenetr Separating Calorimeter



120	31.35
140	26.87
160	23.51
180	20.90
200	18.81

From which the curve marked 1% moisture is plotted as shown. The same method is followed for each of the other curves.

The calculatons are not laborious since, e. g. in the case for m=1

Pt=3762

Assume convenient values for P suggested by the scale and find t by division or with the slide rule.

Similarly,

for m=2	Pt=1912
3	1228
4	912
5	722

For convenience, the scale of gauge pressures is also given on the chart.

It is believed that this chart is sufficiently accurate for all practical purposes.

By using a larger scale for the values of t the chart could be easily extended to include iso-moisture curves for percentages greater than 5%.

A complete chart should also indicate the "limit line" for the throttling calorimeter.

It is the intention of the writer to prepare additional charts for the higher percentages of moisture and a table to facilitate reducing stop-watch readings to minutes and decimals thereof. The complete set should be a useful adjunct to the very useful instrument devised by Professor Carpenter.

PRODUCER GAS ENGINES

G. W. BISSELL.

Presented to the Engineers' Lyceum and Des Moines Engineers' Club, March 1, 1907.

A producer in this connection is a furnace or stove designed to secure what is usually considered undesirable, viz.,

the incomplete combustion of solid fuel, usually coal, but sometimes lignite or peat.

The incomplete combustion is secured by admitting to the fuel only a limited supply of air and control is effected largely by varying the depth of the fire so as to vary its resistance to the air which tends to pass through it due to the force of the draught. In brief, the process is as follows:

The oxygen of the air entering the producer and coming in contact with the incandescent carbon of the fuel forms a certain amount of gaseous incombustible carbonic acid (CO_2). The heat generated by this reaction is taken up by the CO_2 and the nitrogen of the air supplied. These ascending gases yield their heat to the fuel above bringing it to incandescence. But in contact with this glowing carbon the CO_2 first formed takes up another portion of carbon, and is thus converted into combustible carbon monoxide (CO), chemically indicated thus:

$$CO_2 + C + \text{heat} = 2CO.$$

In absence of impurities in the fuel and with dry air, the gas contains all the nitrogen of the air and approximates
Carbon monoxide (CO).....34.7 per cent) by volume,
Nitrogen (NO).............65.3 per cent)
and has a heating value of about 118 British thermal units per cubic foot.

In practice, with carbonized fuel and an air blast, it contains always some CO_2 and a little H with the N of the air. The H arises either from the fuel or the decomposition of the moisture in the air supplied upon its contact with the glowing carbon thus:

$$H_2O + C + \text{heat} = H_2 + CO.$$

With uncarbonized fuels, as soft coals, the products of distillation of the raw fuel in the upper zone are mixed with those of the gasification below. They consist chiefly of H, and the Hydrocarbons, Marsh Gas (CH_4) and Olefiant Gas (C_2H_4).

The amount and quality of gas thus produced varies with the properties of the fuel and type and handling of the apparatus. Thus:

1 lb. Coke or charcoal yields	104 cu. ft. Gas
Anthracite	85
Bituminous	75

Brown coal	55
Turf	45
Wood	35

Anthracite producer gas averages 138 B. T. U. per cu. ft. and has chemical composition by volume as follows:

	Per Cent		
CO_2, Carbon Dioxide, "Carbonic Acid"..	6.0	to	1.5
CO, Carbon Monoxide................	22.0	to	30.0
H, Hydrogen	15.0		7.0
CH_4, Methane, Marsh Gas...........	3.0		1.5
N, Nitrogen........................	54.0		60.0
	100.0		100.0

Producer gas from bituminous coal analyses nearly the same except that CH_4 and H are sometimes higher.

By careful design and management a producer may have an efficiency of 75% which means that the gas contains, when it goes to the engine, 75% of the potential heat of the fuel from which it is generated.

This is practically the same efficiency as is obtained with a good steam boiler. That is to say the steam delivered by a boiler to an engine contains 75% of the potential heat in the fuel which generates it.

Therefore we may say that so far as the generation of the working fluid or medium is concerned the steam engine and the gas engine are approximately on a par one with the other.

Experience shows, however, that the gas engine is generally more efficient than the steam engine as measured by the fuel cost per unit of useful power.

The U. S. Geological Survey Tests show that for 150 Kilo watt units, a producer gas engine used 2.29 lbs. of coal as against 5.71 lbs. per K. W. H. for a steam engine having a water rate of 23.6 lbs. per I. H. P. per hour.

The reason for this must be, therefore, in the superior manner of utilizing the energy available in the working fluid.

The efficiency of a steam engine is surprisingly low. A water rate of 20 lbs. of steam per I. H. P. hour at 125 lbs. pressure and a vacuum of 26 inches is an efficiency of only 11.6% as referred to the steam, or 8.7 as referred to good fuel used in a good boiler by a skilled attendant.

The corresponding figures per brake horsepower are 10.4 and 7.8% respectively.

According to the experience of many users and designers and experimenters the gas engine has efficiencies ranging from 20 to 30% referred to gas or 15 to 25% referred to fuel. These are conservative figures.

The average fuel efficiency of the U. S. Geological Survey producer gas engine (200 H. P.) is approximately 15%.

The writer presents in this connection the principal and most interesting results of tests of a producer gas engine installed for electric light service in Algona, Iowa.*

The engine was a three-clyinder vertical single acting engine rated at 150 Brake horsepower and guaranteed to develop one-half its horsepower at not to exceed 1.5 lbs. Anthracite Pea Coal per B. H. P. Cylinders 15x18. 250 R. P. M.

The producer was of the suction type and was furnished with vaporizer, scrubber, etc. The engine was started by compressed air supplied from storage tanks filled by a small compressor driven by a small engine which served also to run a small fan blower for starting the producer and to elevate coal to the storage hopper.

The engine was belted to a 75 K. W. 2-phase Westinghouse generator and exciter. For purposes of brake tests the belt was thrown off and a prony brake applied to a special brake pulley loaned and placed by the makers.

All usual and necessary precautions were taken in securing the data.

The results of the tests were as follows:

Date	Run	Duration hours	Average B. H. P.	Per Cent of Rating	Coal as fired per B. H. P.	Total efficiency from coal*
3/1/06	I	6	40.1	26.8	1.51	15.69
3/2/06	II	7	82.5	55.	1.15	17.56
3/3/06	III	6	156.9	104.2	0.99	19.69

*B. T. U. in coal, 13,315 per lb. dry coal=12,904 B. T. U. per lb. as fired.

Following is the heat balance for Run III of Brake Load tests:

*From thesis by Messrs. O. E. Lingren and L. J. Wilkinson.

HEAT BALANCE AT FULL LOAD.

B. T. U. in coal as fired, 941 lbs.		100%	12,143,500
" in B. H. P.	2,391,524	19.69	
" " Unburned coal in ash, 104.8 lbs.	1,382,000	11.46	
" " Radiation from Producer	285,000	2.35	
" " Radiation from Scrubber	39,000	.32	
" " Vaporizer	79,000	.65	
" " Scrubber Water	887,000	7.31	
" " Jacket Water	2 539,000	20.90	
" " Exhaust Gases	3,856,000	31.80	
" " Unaccounted for	684,976	5.52	
	12,143,500	100.00	12,143,500

Time does not permit presenting further figures exhibiting the superior economy of the producer gas engine.

The writer believes that the gas engine is to be an important factor in power plant practice in units of all sizes and its entrance into this field is already almost a triumphal march.

There will always be some situations in which the installation of a gas engine instead of a steam engine cannot be justified notwithstanding the above superiority.

One or two such will be cited.

A. Since a gas engine installation costs from 30 to 60% more than the steam plant which would be selected for the specified duty, the net saving, i. e., after paying fixed as well as operating charges, will reduce with the price per ton of the cheapest fuel available in the locality in question. Roughly, with coal at $1.25 or less per ton the wisdom of installing a gas engine would be questionable from the commercial point of view, unless smoke prevention were a financial or aesthetic consideration.

B. A gas engine plant calls for higher average skill and consequently cost of attendants, and repairs are difficult in many cases.

C. The cost of jacket water may be prohibitive.

D. Where heat as well as power is required the steam engine at present has a long lead on the gas engne.

E. Overload conditions are not so easily met by the gas engine as by the steam engine.

The writer ventures to predict that the demand for smokeless combustion and for heating by use of by-products will result in the devising means of utilizing the heat in

jacket water and exhaust gases of the gas engine. These items of waste heat amount to 50% of the heat in the fuel and can readily be utilized, although such utilization will require much more expensive installation than is required for ordinary steam or hot water heating.

When this combination of power and heat can be built with the gas engine as a center the owner will have a more economical plant than now and the long suffering public will get an occasional glimpse of clear sky and a more wholesome air to breathe.

The limits of this paper do not permit a discussion of the mechanical features of gas producer or engine.

These features have been rapidly evolved by the inventors, designers and engineers of Europe and America, and a gas-producer plant can today be purchased, installed and operated to the satisfaction of all concerned in localities where fuel values warrant their use.

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portant equipment will have more to do with easy, rapid and accurate work, than will the particular instrument selected, granted only that it is of good make. There will probably be one instrument for all the surveying and leveling. It is evident that it must be an all-round instrument, and that if it is to fill all its functions in the very best way, it must possess a number of conflicting qualities. In such a case the selection of the instrument becomes a matter of compromise. It must be of high enough grade to allow of good triangulation work and not too sensitive for rough usage; light enough to carry around the surface, and on distant surveys in a mountainous country, and the horizontal circle graduated to 20 seconds of arc. For average surface work, moderately high magnifying powers are demanded, but the underground work will be at close range, and in poor light where small magnification is better. Taking all things into consideration, probably a 4 to 4 1-2 inch horizontal circle reading to 20 seconds, full vertical circle, U-shaped standards, light mountain transit will outline the best instrument for the work. It should be procured from the best American manufacturers, and will be expensive. Something can be saved by omitting some of the usual extras. The U-standards and small circle will do away with a compass in the usual place. This omission will be disproved of by some, largely from habit, the author believes. As a matter of fact, the compass, as an attachment to the transit, does not earn its salt, and is a distinct disadvantage in the correct construction of the instrument itself. That the compass is not used, in fact scarcely expected to be used, is shown by its being put in the most inconvenient place for reading, and where at best, it cannot be read accurately. The best place for the compass is in a trough which can be placed on the telescope and taken off or on as occasion requires. The length is then not limited to the distance between standards, but to the length of the telescope. It is therefore more accurate, since the sensitiveness of a needle is proportional to its length; it is in the proper position for observation, and the angle between the magnifying needle and the point to be observed can be accurately measured and read on the transit verniers. This arrangement should satisfy the most exacting. Those who merely use the compass occasionally to guard against gross errors of angle reading, will find a pocket compass sufficient. The latter, especially if it is a Brunton pocket transit, can be used to advantage in taking side notes. The U-standard offers so many decidedly valuable constructive advantages that its use is to be always recommended. It will permit of lighter and at the same time more substantial construction. It presents a better appearance and is less apt to get out of order. Many would hesitate to use a 4 inch horizontal circle in triangulation work, but the

amount of such work is small, permitting of extra care in repeating angles and of doing it on clear, still days.

An auxiliary telescope is not so much of a necessity for this class of work as is usually supposed. Certainly if the shafts follow a vein inclined at the impossible angle for one telescope, and if there is a reasonable amount of such work to do, the purchase of the extra telescope is justified. But if its use is only a convenience once or twice a year a makeshift* method should be used when required and the $50.00, more or less, saved, used in the purchase of conveniences which will pay their way.

Don't stint on tapes. A 100 foot tape will be the standard and if only one such is purchased, it will not last very long. A number of men in the party or around the mine can use a tape and probably only one man the instrument. Get two or more vest pocket tapes for measuring H, I's, H, Pt's and side notes. A long tape, 300 or even 500 feet in length, will pay for itself in a short time in surface work in a rough country. A good many mine measurements fall between one hundred and two hundred feet, so a two hundred foot tape is sometimes just the thing. It will pay to study the question of tapes carefully. There is just one manufacturer of good tapes in the country, but this is not an advertisement. Have all graduations in feet and tenths or finer and the other side blank, not in feet and inches, This last leads to confusion, sometimes to errors, and encourages borrowing habits on the part of the mine carpenter and timberman.

A good reel for each tape is a necessity, making for a contented chainman and a long-lived tape. The tape manufacturer provides fancy reels which nine times out of ten are worthless. Unless absolutely sure of the make, the reels should be left out of the order and the mine blacksmith consulted.

Inexperienced help will be the rule, therefore all practical small conveniences should be ordered. For example, levels for plumbing rods will save time and temper. In the office the stadia slide-rule will be a great convenience in working up topography. The busy surveyor will be amply justified in ordering slide-rules and log and traverse tables.

The office exists mainly to furnish a place to work on the mine maps and to consult them. The place of honor should be furnished the map tables. The scale to which these maps are drawn will depend on the amount of detail to be shown. Not much can be given on a scale of more than fifty feet to the inch. Many mines of the character considered have a length of a mile on the lode and a width of two claims or 1200 feet. If one

*For a method of carrying a survey down a shaft by transit without auxiliary telescope, see Engineering and Mining Journal, May 16, 1903.

map is used a sheet 60" x 106" will be required. Frequently mines have maps of this size and larger, with no better means of drawing on them than a flat table of the same size. The draftsman must stretch out flat on them when working up the middle areas. There is no better back breaking devise made. The maps are always dirty and in poor shape. The whole work is a botch and a money loser.

It will pay in the beginning to give the present and future needs of the mine, in the matter of maps, a thorough study. Without going into the subject very deeply, it may be pointed out that the facts to be shown on mine maps naturally group themselves as follows. Those facts which illustrate the character of the surface ground and improvements and their relation to points underground; the kind, extent and nature of ground penetrated in all underground openings; geological data, surface and underground, and metallurgical facts, as the value and kind of ore. There use follows two general lines; they are the official records of the past and present development of the mine, and they are essential or of great help in planning development work and improvements.

Whether there should be a set of maps for each of these groups of facts will depend upon the individual case. In general the work of mapping will be greatly systematized and the readiness with which the maps can be consulted and made of practical use, improved if the attempt to attain the impossible be abandoned in the beginning. All details cannot be shown on one map nor is it desirable that they should be. Take the surface group for illustration. One map will be needed, showing property lines, roads, trails, buildings, streams, etc., and for the surveyor's convenience, some of the permanent survey points. So far a small scale only is needed, in fact the small scale is better, since the eye can grasp essential facts, when brought together on one compact sheet better than scattered over a larger surface. Some parts of the surface, however, for example around the shafts and mill, require greater detail. This data should be given on separate sheets, called detail sheets and finished as required. Their number, the scale, etc., should be planned in the beginning, their position shown on the main map, and reference points given on each detail sheet, so they can be brought together and displayed as a whole. The underground facts should be treated in the same way. In order to make the plan a consistent one, a style sheet should be worked out in the beginning, showing just what facts are to be placed on the main map, what on the detail sheets and just how each fact is to be represented. With this style of mapping the equipment of the office is simplified. The maps will all be of the same size on Whatman's mounted

drawing paper or similar material, and drawn on a convenient drawing table. All maps can be kept flat and filed in drawers in a compact manner away from dust. If the powers that be demand all details on a large map of small scale then a long table with rounded edges and rollers underneath for taking care of the extra width is needed. Some protection should be provided for the map where it passes over the edge of the table.

Before surveying begins, the surveyor should look over the field, and fix upon the proper position for permanent monuments. The system should be planned as a whole, allowing of course, ample room for expansion. With good judgment in their selection, a small number of triangulation stations can do such excellent service that any point required on the mine surface can be reached by a 300 foot tape from the instrument set up within view of two triangulation stations, if the country is suited to triangulation work at all.

Any survey worth doing, is worth doing well and preserving both in the notes, and on the ground, unless from its nature it is a temporary affair. Beware of the word temporary—no one can always surely say what will be temporary or permanent in a survey. This question will soon arise, "What degree of accuracy is necessary?" It is usually considered accurate enough in a mine survey if the closure is within a sphere of one foot. So far as any one closed survey is concerned this is certainly good enough, but who can tell what the end of any particular survey will be? A successor may pick up an intermediate point and project it on into an important survey, and the first surveyor become discredited. There is a satisfaction in doing good work with good closings, that is of far reaching effect in the *esprit de corps* of any surveying party. Beware of slovenly habits. Is any one gifted enough to say just what amount of slovenly work can be done in any particular case, resulting in just the allowable eror and no more? After all how much is saved by doing unimportant work just a little bit carelessly? The survey in which the closure allowed is say one foot, may, in fact, nearly always does, cost just as much as the one in which the allowed survey is say .2 feet.

Note-books are a source of trouble in any survey more especially in underground work. The surveyor who can keep a clean note book which tells any other surveyor just what was done and how, in a wet mine, using candles for light is a rare man. This greasy book has to be handled in the office when mapping, causing soiled hands and maps. Again if an engineer is employed in the office he will often need the book when it is in use underground. Bad as the note book is it is better than the opposite plan of taking notes on scrap paper and transferring them to

clean note-books. This practice prevails at one well known mine. It is hardly necessary to point out its faults.

The author has tried the following plan which seems to eliminate all difficulties. Cards of the size of ordinary filing cards, are ruled in columns for note taking. Sheets of paper of the same size are ruled in the same way. These are placed in an envelope of oiled paper, the front of the envelope being printed with the same form as the card, and bears the same serial number. For note taking the outside of the envelope is used but copies are preserved on the card and sheet by means of carbon paper. The clean card is filed in a card index cabinet and is not to be removed from the office, while the sheet is kept in a loose leaf note-book, which can be carried whenever it is needed. By good indexing and use of different colored cards for each class of surveys, all notes become instantly accessible at all times, no matter what note-book happens to be out of the office.

PRODUCER GAS ENGINES

For Iowa Electrical Association, Clinton, Iowa, April 19, 1907.

BY G. W. BISSELL.

Attention is invited to certain tests made by the United States Geological Survey during the period of the Louisiana Purchase Exposition and at the government testing plant established there. These tests can be studied in detail by referring to Bulletin No. 261, United States Geological Survey, obtainable through your Congressman, or by direct application to the Survey at Washington.

TABLE I.

SAMPLES	B. T. U. per lb. dry coal		Average K. W. at switchboard		Dry Coal per K. P. hour		Rates of Economy
	Steam Plant	Producer Plant	Steam Plant	Producer Plant	Steam Plant	Producer Plant	
Alabama No. 2	12,555	13,365	158	148	5.50	2.21	2.48
Colorado No. 1	12,577	12,245	115	148	6.51	2.30	2.83
Illinois No. 3	12,857	13,041	147	148	5.85	2.41	2.43
Illinois No. 4	12,459	12,834	145	148	6.47	2.37	2.73
Indiana No. 1	13,377	13,037	163	148	5.56	2.60	2.14
Indiana No. 2	12,452	12,953	142	149	5.85	2.08	2.81
Indian Territory No. 1	12,834	13,455	143	152	5.44	2.46	2.21
Kentucky No. 3	13,036	13,226	155	148	5.68	2.57	2.21
Missouri No. 2	11,500	11,882	152	128	6.62	2.30	2.88
West Virginia No. 1	14,198	14,396	146	148	5.25	2.12	2.48
West Virginia No. 4	14,002	14,202	157	148	4.87	1.74	2.78
West Virginia No. 9	14,616	14,580	154	149	4.68	2.14	2.18
West Virginia No. 12	15,170	14,825	151	148	4.75	2.02	2.35
Wyoming No. 2	10,897	10,656	135	149	7.94	2.78	2.85
Averages	13,037	13,192			5.77	2.29	2.49

In Table No. I are shown the principal results of steam and producer gas engine tests of certain soft coals, some of which

are comparable with Iowa coals. Fourteen tests are here quoted. The favorable showing of the Producer Gas Engine in these tests is significant. While it is true that the steam engine used was a simple non-condensing engine having a "water-rate" of 23.6 pounds, it is also true that the gas engine in the large sizes is still in an experimental stage especially in those features of its design and operation which affect its utility in plants where only ordinary skill can be expected to be exercised.

Of the coals listed in Table I, Missouri No. 2 resembles most closely the Iowa coals—its principal properties being

Moisture	11.60
Carbon, Volatile	35.28
Carbon, Fixed	38.28
Ash	14.84
Sulphur	4.56
Calorific Value	11500 to 11882

and the average of Iowa coals being

Moisture	13.16
Carbon, Volatile	33.36
Carbon, Fixed	39.69
Ash	14.84
Sulphur	4.56
Calorific Value	10019 to 11027

"The high percentage of sulphur in the coal did not add to its value as a producer fuel," is a remark made in the government report in connection with these tests, which opinion has been modified materially in the view of later experience to which reference is had below.

The lack of correspondence between the relative values of the several coals in Table I for steam and producer tests indicates that a given producer may be better adapted for handling a wide variety of coals than is a given boiler furnace.

The table also shows that for these tests and conditions the percentage saving in fuel of the producer over the steam plant is greater for the poorer coals, and this is an entirely reasonable view because the volatile constituents of the coal in the producer escape only through the engine cylinder in which their combustion is completely effected; whereas, with steam generation with volatile fuels under a boiler, various and large proportions of the volatile matter escape to the chimney unburned.

The tests above quoted were largely in the nature of preliminary tests and considerable difficulties were met with in obtaining reliable results.

In the year following the exposition, viz., 1905, better arrangements were available for the tests, and the matter was entered into much more thoroughly. A notable change in the conditions surrounding the second series of tests was in their length.

It was possible to secure continuous periods of operation for each tests of from forty to sixty hours, which was not possible in the earlier tests.

TABLE II.

SAMPLES	B. T. U. per lb. Dry Coal	Cash	Sulpher	Dry Coal per K. W. hour		Ratio
				Steam	Producer	
Illinois No. 6	12762	16.0	4.6	7.13	2.40	2.98
7	12730	18.9	4.15	5.85	3.50	1.67
8	12020	11.6	4.64	7.41	2.31	3.20
9	12438	11.5	4.92	7.00	2.38	2.94
10	12929	10.6	1.35	7.70	1.95	3.95
11	12348	10.8	2.09	6.02	1.82	3.32
washed 11	13370	11.5	1.65	6.62	4.00	1.65
13	12600	10.2	1.66	6.12	2.14	2.87
14	12060	12.4	4.16	7.16	2.10	3.40
15	11749	13.5	4.06	6.82	2.18	3.14
16	12874	10.3	1.47	5.70	2.25	2.54
18	12970	10.0	4.59	6.40	2.03	3.15
19	13000	9.4	0.53	5.65	1.79	3.16
Average						2.92
Indiana No. 5	12600	11.50	5.00	6.41	2.20	2.92
Indiana No. 6	12505	12.5	4.71	6.41	2.32	2.77
Kansas No. 5		10.2	3.18		2.02	
Kentucky No. 5	14500	4.0	0.47	4.83	1.79	2.69
Dakota Lignite		11.4	3.54		2.55	
West Virginia	14500	3.5	0.82	4.64	1.36	3.41
Wyoming	10518	15.3	7.36	7.96	2.40	3.31
Brazil	9900	23.4	2.94	8.85	3.12	2.84
Average except Illinois						2.99
Average of all						2.93

Table II gives a comparative summary of a number of soft coals tested in 1905, both on the steam plant and the producer plant. The results are very interesting and confirm in a general way the advantages of the producer plant indicated by the earlier tests. In the earlier tests, as shown in Table I the ratio of economy of the producer to the steam plant was 2.49. In the tests of 1905, the average ratio for the Illinois coals was 2.92, and for sundry other coals used, 2.99, and for the nineteen coals as shown in Table II, the average was 2.93.

The following summary of the 1905 tests is taken from Bulletin No. 290, United States Geological Survey:

"The results of the majority of the tests have been exceedingly gratifying, official records having been made as low as 0.95 pound of dry coal per hour burned in the producer per electrical horsepower developed at the switchboard, or 0.80 pound of dry coal per hour burned in the producer per brake horsepower, on the basis of an assumed efficiency of 85 per cent for generator and belt.

"Throughout the tests a constant effort has been made to do away with unnecessary appliances. This effort has furnished valuable and interesting information and has centered attention on several radical changes in the details of producer gas plant consruction.

"It was found at an early date that more or less sulphur was passing the purifier and entering the engine cylinders. Investigations by the chemists showed that purifiers consisting of oxidized iron filings and shavings are fairly efficient for coals containing little sulphur—1 per cent or less; but it was found that for coals containing larger percentages of sulphur the purifier became completely exhausted after about six or eight hours. Mixtures of lime and shavings were tried, but with little success. As a result of these investigations, the purifier has been discarded, and the gas, carrying its full percentage of sulphur, has been charged directly into the engine cylinders. This method of operating has been going on for many months, and no ill effects have been discovered, though coal has been used containing as high as 8.1 per cent of sulphur.

"One feature of the plant as installed was the economizer, used for preheating the air for the blast. A series of experiments has shown no effect on the chemical composition of the gas or on the efficiency of the plant when air at ordinary atmospheric temperature was substituted for preheated air. As a result the economizer, as an economizer, has been discarded, and the construction of the plant again simplified.

"Other modifications and changes are under investigation at the present time, the most important, from an economic standpoint relating to the utilization of slack coal in producers."

In addition to the above the writer presents the principal results of a test of a hard coal producer gas engine made under his direction, in the spring of 1906. The engine was a three-cylinder, vertical, Fairbanks-Morse engine, at Algona, Iowa, using gas generated from anthracite pea coal in a suction gas producer, also manufactured by the Fairbanks Morse Co. The unit is rated at 150 brake horsepower at 250 revolutions per minute, and was guaranteed to give one brake horsepower hour for not to exceed 1 1-2 lbs. of anthracite pea coal for all loads above 75 brake horsepower.

TABLE III.

Revs. per min.	Brake Load Horsepower	Lbs Coal (as fired) per brake horsepower per hour.	Cost per brake horsepower hour at $6.00 per ton.
250	40.1	1.511	$0.00453
250	82.7	1.157	.00347
250	156.9	0.999	.00299

Following is the heat balance for the third of the Brake Load tests:

HEAT BALANCE AT FULL LOAD.

B. T. U. in coal as fired, 941 lbs.		100 %	12,143,500
B. T. U. in B. H. P.	2,391,524	19.69	
B. T. U. in unburned coal in ash			
B. T. U. in 103.8 lbs.	1,382,000	11.46	
B. T. U. in Radiation from Producer	285,000	2.35	
B. T. U. in Radiation from Scrubber	39,000	.32	
B. T. U. in Vaporizer	79,000	.65	
B. T. U. in Scrubber Water	887,000	7.31	
B. T. U. in Jacket Water	2,539,000	20.90	
B. T. U. in Exhaust Gases	3,856,000	31.80	
B. T. U. Unaccounted for	684,976	5.52	
	12,143,500	100.00	12,143,500

Two tests were also made on this engine under service conditions, viz.: Belted to a 75 K. W. alternating current generator. In addition to the lighting load, electrically driven pumping machinery can be operated from this generator.

Fig. 1 shows the load curve (A) during a service run with lighting load only and the load curve (B) for the combined load, the usual operating conditions, stand-by losses included.

At \$6.00 per ton the cost of fuel per K. W. hour at the switchboard for the load A was \$.01207 including fuel for bank-

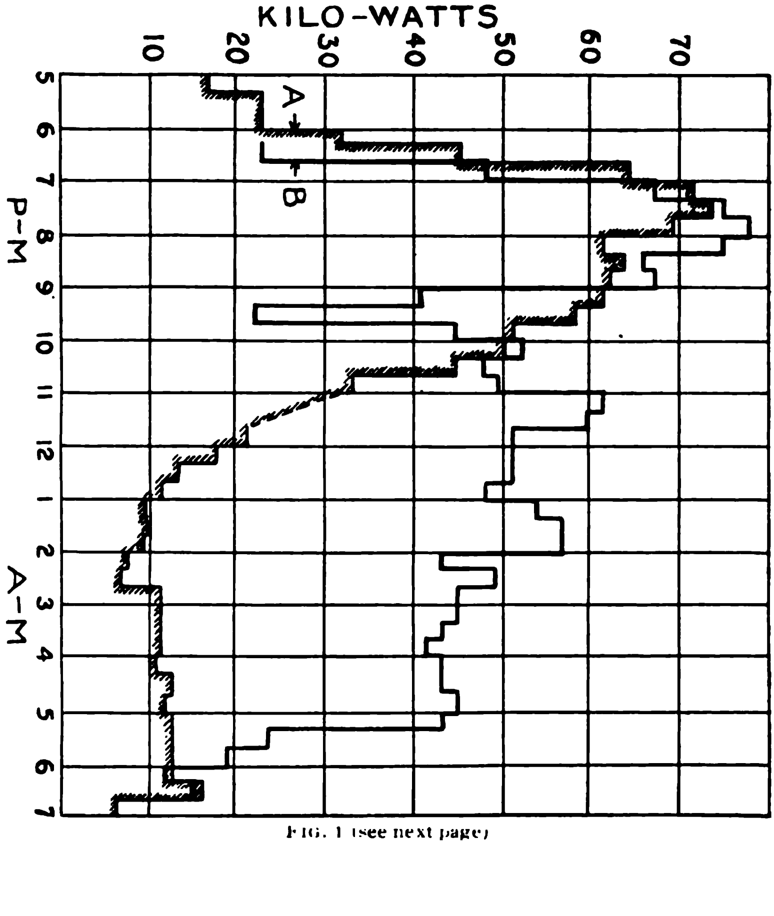


FIG. 1 (see next page)

ing and starting, and for the load B was $.00639 including also the stand-by losses.

Soft coal from Illinois which was used for a Corliss engine unit built in the same plant cost $3.40 per ton.

A.—Load Curve of Algona Producer Gas Engine, March 15-16, 1906.

14 hour test. Output 409 K. W. hours.

Anthracite Pea Coal per K. W. H.=4.10 lbs.

Fuel cost per K. W. H.=$0.0123.

Load factor 27%.

B.—Load curve of Algona Producer Gas Engine, March 16-17, 1906.

12-hour test. Output 589 K. W. hours.

Anthracite Pea Coal per K. W. H.=2.23.

Fuel cost per K. W. H.=$0.00699.

Load factor 18%.

For the purpose of comparison with this test, we may consider the case of a simple Corliss engine similar to that used in the government tests at St. Louis. The average coal consumption of that engine, according to Table I, was 5.71 pounds per K. W. hour. If this coal cost $3.00 per ton the cost of the coal per K. W. hour would be $0.0085, which can be compared directly with the values given in connection with the full load test of the Algona engine, viz., $0.0029.

It is difficult at this time to predict the immediate future of the producer gas engine, but the writer believes that this type of prime mover is destined to be a formidable rival of the steam engine, and as the price of fuel increases the field for the producer gas engine will enlarge. At present there is a question whether it will pay to install a producer gas engine where coal is cheap. The only advantage would be the compliance with smoke regulations, but as a financial proposition it may be stated that owing to the fact that a producer gas engine installation costs probably from 40% to 60% more than a steam engine plant which would be its alternate, it will not pay to consider the installation of the gas producer plant with coal costing $1.50 or less per ton, for 24-hour uniform power. The turning price would be higher for low load factor. Just how much can not be stated as a general proposition, owing to lack of data.

The question of the mechanical and operative advantages and disadvantages of the gas engine will not be discussed here except to say that there is no reason why the gas engine cannot be used satisfactorily for the generation of electrical current for light and power. Another very important factor in a just comparison of the steam and the gas engine may be the water.

Please mention The Iowa Engineer when you write.

The property east of Depew Place extending to Lexington Avenue contained four- and five-story apartment houses, and that west of Vanderbilt Avenue to Madison Avenue buildings occupied by the American and Adams Express Companies.

The foundation of the old yard consists of what may be called solid rock overlain with a cinder fill of about ten feet. The rock does not occur in strata but seems to be irregular and intermingled with clay. In some places however the rock is in layers having a dip of about thirty degrees, but the dip is not constant nor the beds uniform in position. On account of these conditions the rock has to be blasted and taken out in such shape that it can be used only for fill.

During the excavation many difficulties were encountered, as the breaking of old water mains and sewers that were not known to exist. Numerous springs developed at the most unexpected places and these with the above mentioned troubles made necessary the use of several pumps until the new drains could be connected with the main sewer. The greatest depth of excavation for the new yard will be about one hundred thirty-five feet, going below the mean high water mark about eighteen feet.

The original plan for the new yard was that it should occupy the same plot as the old yard and include below the express tracks, a suburban station containing eight tracks. The total width was to be but one hundred and ninety-five feet. No subways for mail or baggage were provided for and, altho new viaducts were to have been erected over the express tracks, the accommodations would not have been noticeably increased. The new yard will occupy the same plot as the old with the addition of the property to the east to Lexington Avenue between Forty-fourth and Fiftieth Streets.

The design for the construction of the new yard divides it into three parts called Bites one, two and three. Bite one includes the part between Lexington Avenue and Depew Place. Depew Place and Vanderbilt Avenue will not run thru the yard but will stop at Forty-fifth Street.

All buildings in Bite one have been removed and the excavation completed. At Fiftieth Street fronting on Lexington Avenue a transformer house has been erected and is now in operation. The tracks are nearly all in place and the third rail installed, the overhead contact rail and all electric conduits are in place and the erection of the cross street viaducts completed to the beginning of Bite two. The trucking subway which connects the Adams and American Express Companies' buildings, located between Forty-eighth and Forty-ninth Streets and Lexington Avenue, with the platforms of the station, the mail subway connecting the Post Office Building with the mail platforms

of the station, all had to be ready for use before any trains could be taken from the Grand Central Station to the Grand Central Palace which is being used as a temporary station.

Along the east line of Depew Place a suburban wall has been built and the excavation will be carried down to provide a subway for suburban trains. The west suburban is on the western line of the yard and between these walls the express tracks will be carried on a steel deck which varies in construction according to the clearance between the suburban and express tracks.

Commencing at Fifty-seventh Street where the four tracks leave the tunnel, the steel deck plate construction was used. This consists of transverse beams spaced about two feet apart carrying a one half inch plate on which the regular track construction rests. This system will be used down to Fiftieth Street. Here the head room will allow the use of transverse girders with a concrete arch between to carry tracks above and this method will be used between Forty-eighth and Fiftieth Streets.

Below Forty-eighth and extending to the terminal the tracks will be carried by transverse girders which take the load from stringers running parallel to the track, or to the north and south center lines.

Owing to the fact that the entire yard will be covered with viaducts and buildings, expansion joints were provided only at the center lines of the cross streets and a longitudinal expansion joint in the center of the yard or the center line of Park Avenue.

All steel will be protected by two or more inches of concrete and the columns footing on the suburban level will be provided with a protection pier extending seven feet above the top of the rails and continuous from column to column except for crossovers and turnouts.

Two inches above the top of the steel deck will be laid a heavy coating of waterproofing. On this will be placed one layer of brick with from four inches to one foot of concrete which latter will carry the standard track construction.

The yard when completed will contain a twenty-story station with train shed covering eighteen express tracks and fifteen suburban tracks. All but two of the suburban tracks are connected to the loop which is under the main part of the station, and is to be connected with the tracks of the Interborough Rapid Transit at Fortieth Street. A platform is provided on each side of the tracks on the suburban level.

A mail subway from the Post Office building will extend across the yards beneath the suburban tracks and will connect with the platforms of both levels by means of elevators.

A trucking platform will connect the American and Adams

Express Companies' buildings with the suburban platforms; and elevators with those on the Express level.

Between the platforms and the suburban wall the pipe gallery will be located. This will carry the electric ducts, compressed air pipes, Pintsch gas and vacuum pipes. At Forty-eighth Street a pipe gallery will extend across the yard below the suburban tracks and connect to a similar gallery in the west yard.

Beginning at Forty-fifth Street on the center line of Park Avenue there will be built a viaduct which will unite with the cross street viaducts at Forty-fifth, sixth, seventh, eighth and ninth Streets. At Fiftieth Street the yard has narrowed so that the width of Park Avenue only is used. The Park Avenue viaduct will end at Fifty-seventh Street where the roadway is carried on the roof of the tunnel.

In the future buildings will be erected over the express tracks between street lines so that in passing down Park Avenue one would scarcely realize that there were two levels of tracks below. No round-houses will be erected and but one turn-table will be installed. The latter will be used to turn observation cars and in other special cases that may arise.

A tunnel will also be built to connect the yard with the Subway on Eleventh Avenue. This cross-town subway will relieve the traffic on the main line trains of the Park Avenue tunnel.

There are several interesting engineering features to this great undertaking as well as a number of practical problems to be met.

The train service has been delayed but very little. As soon as a new piece of track can be used an old one is released and excavation started, the steel being erected at once any of the excavation is complete and that part put into operation as soon as possible.

The trains in the old yard depart from the west side but in the new yard they will arrive on the west side. It is the intention to make this change in one night so that traffic will suffer no delay. The signals, towers and interlocking devices are all ready to be installed for the change.

The wrecking of the old train shed offers a very interesting problem. The shed was built in 1871 of wrought iron imported from England. It consists of thirty-one arches spaced about twenty feet center to center, each having a span of two hundred feet and a rise of ninety feet. The thrust of the arches is taken by rods running beneath the tracks.

Although the design of the arches was for three hinges, the actual construction is of the two hinge type. The design of the arch is such as to necessitate the removal of each truss in

five sections, each section about two tons in weight. Corrosion has reduced the cross section of the iron on an average one sixteenth of an inch although in the maximum case one eighth inch has been removed.

The wrecking will start from Forty-fifth Street and progress southward. As soon as one section is removed, the contractor will be required to erect canopies over the platforms so that they will be covered continually. Owing to the short time each day that the traffic will permit of wrecking operations, the work will of necessity be executed under many difficulties. It must however be left in a finished condition at the end of each working period which will be from 10 p. m. to 5 a. m.

Some idea of the magnitude of the work may be gathered from the following facts.

The suburban station will cover twenty-two acres, and the express level thirty-nine acres; total, sixty-one acres.

There will be constructed one and three quarters miles of new steel viaduct requiring one hundred thousand tons of steel; two hundred and sixty thousand cubic yards of concrete necessitating three million cubic yards of excavation.

There will be twenty-five miles of tracks within the yard accommodating twelve hundred cars; eighteen interlocking plants; eighteen signal towers; thirteen battery houses.

Seven hundred and fifty tons of transmission copper wire will be used in eighty-nine miles of cable in conduits, and forty-eight miles of cable on poles.

Eight power stations of seven thousand horse power each will supply the power. Thirty-five twenty-two hundred horse power electric locomotives will be used, each weighing one hundred tons and having a maximum speed of eighty miles per hour; also, one hundred twenty four hundred horse power motor cars each weighing fifty three tons and capable of a maximum speed of fifty-two miles per hour. Only the suburban trains use electricity at present and fifty-five all steel multiple unit cars each weighing forty-one tons have been put in operation.

These improvements, although a large undertaking and ranking next to the Panama Canal in magnitude, mean a great saving to the operating department. The amount of this economy from the pecuniary standpoint will more than pay the interest on the ten millions of dollars which the undertaking is estimated to cost.

An average daily force of ten thousand men will be employed to carry on this work, which, it is estimated will be completed by January first, 1910.

A COMPARISON OF STRUCTURAL STEEL SHOPS

BY J. E. VAN LIEW, C. E.

Of the large number of structural steel shops visited, the writer has found a wide variation in general layouts, and in the methods of handling material. With the subject of this paper in mind, the following seven shops with a capacity of 24,000 tons to 1000 tons per month, have been inspected: American Bridge Plant, Toledo, Ohio; American Bridge Plant, St. Louis, Mo.; Illinois Steel Company, Chicago, Ill.; Smeeth Foundry Company, Chicago, Ill.; Des Moines Bridge & Iron Works, Des Moines, Iowa; Chicago Bridge and Iron Works, Chicago, Ill.; Kenwood Bridge Company, Chicago, Ill.

The following eleven shops with a capacity of one hundred tons to 1000 tons per month were also visited: Christopher & Simpson Iron Works, St. Louis, Mo.; Stupp Bros. Bridge Company, St. Louis, Mo.; Paxton and Vierling Iron Works, Omaha, Neb.; Kansas City Wire and Iron Works, Kansas City, Mo.; Ottumwa Bridge Works, Ottumwa, Iowa; Bartlett & Mitchell Iron Company, Kansas City, Mo.; Bartlett Steel Company, Joplin, Mo.; Westover Iron Works, Lincoln, Neb.; Marshalltown Foundry Company, Marshalltown, Iowa; Banner Iron Works, St. Louis, Mo.; Ryerson's Iron Company, Chicago, Ill.

Of the larger shops, those handling mostly heavy steel and doing a large amount of reamed work are the Ambridge, Chicago and Toledo Branches of the American Bridge Company; Toledo Massilon Bridge Company, and the Smeeth Company of Chicago.

The shops handling larger work are the St. Louis branch of the American Bridge Co., or the Koken Iron Works, the Des Moines Bridge & Iron Works, and the Kenwood Bridge Company.

AMERICAN BRIDGE COMPANY, AMBRIDGE, PA.

The Ambridge shop of the American Bridge Company has an output of about 24,000 tons per month of heavy railroad bridge and structural material with a proportionate amount of lighter work. The plant employs 5000 men in addition to 1000 men in the clerical and engineering departments. The plant has a roof area of over fifteen acres and cost $5,000,000. The main bridge shop is two hundred seventy feet wide and six hundred forty-eight feet long with a transcept across the end one hundred twenty-eight by three hundred thirty feet, both parts adjoining and symmetrical with the center line of the shop. It is stated that when this shop was first started in 1903, before the movement of material through the shop became systematized, complete jobs were often lost track of and located only with difficulty.

The raw material is delivered from longitudinal tracks to a stock-yard at the center of the plant commanded by overhead cranes of ten and twenty tons capacity. As the stock is needed it passes through the main shop undergoing the successive operations of fabrication and emerging at the opposite end ready for shipment or storage, or to be taken to another shop for work of a different nature.

The main shop covers over five acres and has a total weight of 5500 tons of steel in its roof trusses, crane girders and columns. It is notable for the wide unobstructed floor space and efficient lighting, direct sunshine being avoided. The roof trusses are supported at the columns and at intermediate points on steel columns. The walls are of concrete which covers the steel columns and bracing between.

The machines are so arranged that when there are a large number of beams to be punched for standard connection or in group of holes, either may be accomplished at one stroke. A great saving in time and labor is thus realized over the smaller shops where the holes are punched one at a time. The web plates of plate girders have a line of holes for the stiffener punched at one stroke. The large punches are so arranged that they can be set to punch any combination or group of holes in the web, as well as in the flanges, of a large number of duplicate beams. No marking or center punching is done, it being necessary only to arrange stops at the end of the beam to hold it at the right place until the group of holes is punched. The beam is first run through the punch on rollers and the web punching made. It is then automatically thrown on edge and the rollers reversed, bringing it through the punch on the opposite side of the machine when the flange punching is made.

The riveting is all done by air. In plate girder work the rivet jaws are raised and lowered in the floor in riveting the stiffener angles. The cover plates are usually riveted to the flange angles first and then to the web plates, the girder remaining stationary. The air riveter is suspended above from a crane that moves along the entire length of the girder.

The reamers are supported by a large bridge or crane just above the material to be reamed. As reaming progresses the multitude of reamers are moved forward or backward on tracks on the floor at each side the steel being treated remaining stationary.

Some of the paint is applied by large brushes twelve inches wide with a handle six feet long, similar to the method of applying whitewash.

In the eye bar department the heads are upset by hydraulic pressure and the pin holes up to fifteen inches in diameter in three inch metals are punched at one stroke by a 1000 hydraulic

punch after which the heads are annealed. All the lifting is done by means of magnets.

AMERICAN BRIDGE COMPANY, TOLEDO, OHIO.

Until the Ambridge plant was built the Toledo branch of the American Bridge Company was one of the most modern structural shops in the United States. This plant was designed for a capicity of 3000 tons per month and like the Ambridge plant handles practically only mill order material. As at Ambridge the material starts at one end of a shop about one hundred fifty feet wide by seven hundred feet long and goes from the shearing machines to the punches and thence to the reamers and planers and finally to the riveter, passing out at the other end of the shop as a finished product. There are ten- and twenty-ton capacity transverse travelling cranes at both the receiving and shipping ends of the main shop as well as in the interior at the shipping end. At the latter point however the cranes run longitudinally for a distance of about one hundred feet over the riveting floor, there being two crane runways side by side with a common support between. These two cranes cover the finishing end of the shop and are used to shift the heavy assembled members and to place them in position to be milled.

At the opposite or receiving end of the shop where the raw material enters a large number of air hoists run on tracks suspended from the bottom chords of the trusses and convey the material across the shop to the punches and shears, and thence to narrow gauge cars on a track that runs lengthwise of the shop. At Ambridge these air hoists are replaced by traveling cranes that run transversely of the building.

The reamers are pivoted on the wall against which they can be swung when not in use.

Built up sections of end posts of bridges running one ton per foot and sixty feet long have been built at this plant; also girders ten and twelve feet deep and one hundred twenty feet long. It is said that one of these sections was loaded on a car wrong end to, and not discovered until after reaching the bridge site. It was then necessary to rehaul the cars a distance of some twenty miles in order to reverse the end post so that it could be handled at the bridge.

This shop has about ten punches and shears arranged at the receiving end. Overhead trusses for about two thirds the length of the shop carry air hoists on a runway suspended about two feet below the bottom chord of the truss. Longitudinal runways to carry air hoists are also arranged at intervals. At machine points a light overhead crane with longitudinal movement is arranged with a track to carry the air hoists transversely, thus permitting the shifting of material in any direction when

being punched or sheared. This provision for both transverse and longitudinal movement of material as well as its handling at machine points has been worked out here with much care. Improvements have been made from time to time until now the shop is turning out five hundred tons more per month than it was designed for. In many of the shops visited the material was handled to machine points by a jib crane. The horizontal arms, provided with a track on which a chain hoist was carried, were arranged to swing about ten feet above the machine. This would permit the placing of material in any desired position.

The power for the Toledo shop is furnished by its own steam plant of 1200 horse power which generates electricity for all its machinery. Each machine is run by a direct connected motor.

The building is heated by steam coils and by hot air from a blower system. The work fabricated at the Toledo plant is all very heavy, being mostly reamed work. All material is ordered direct from the mill cut to length.

AMERICAN BRIDGE COMPANY, ST. LOUIS, MO.

This shop is known as the Koken branch of the American Bridge Company. It carries a large stock of material in long lengths and takes care of the quick delivery orders which usually are for very light material. This plant has a capacity of about eight hundred tons per month of structural material. There are four large punches with shearing attachments, an angle shear and a Pels beam shear.

The structural shop includes an area about ninety by one hundred fifty feet, covered with steel trusses, on the bottom chords of which run small cranes. Each crane, which is operated by hand chain-ropes, extends between two trusses. These cranes run transversely of the shop and support air hoists which run longitudinally. The total floor area is thus reached by the air hoists.

At the finishing end of the shop where the heavy material is riveted an overhead crane of ten tons capacity enters picking up the material and carrying it to the cars outside.

MASSILON TOLEDO BRIDGE COMPANY, TOLEDO, OHIO.

The Massilon Toledo Bridge shop is about eighty feet wide by three hundred feet long. All roof trusses are of the low camel-back type carrying on the bottom chord air hoists running transversely in the shop. At each machine point, which are located between trusses, a crane is placed with a runway to carry a hoist, permitting of longitudinal movement of material between trusses, and readily permitting the furnishing of material to the machines. The movement of material forward is by

narrow gauge cars, the material being brought to the same by the transverse hoists or by the small cranes between trusses at the machine points. This shop is equipped for heavy railroad work requiring much reaming and milling. At the lower end of the shop are two riveting floors each about seventy-five feet long. One is at either side of the center and is reached by a ten-ton crane supported above it. The riveting machines are carried by a jib crane running along the center line of the crane support.

CHRISTOPHER & SIMPSON PLANT, ST. LOUIS, MO.

The Christoprer & Simpson main shop is about seventy-five feet wide by one hundred twenty-five feet long and contains one universal punch and shear, one angle shear, and one bevel plate shear. The capacity is about eight hundred tons per month. A stock of 1000 tons is carried on hand. One feature characteristic of this shop is the fact that it is not located on any raidroad, all the raw material has to be hauled in by wagon, and the fabricated material hauled away again. At this plant the detail punch is across the street from the main shop. After all details are punched the steel is assembled in the main shop, either by wheel-barrows or by wagons. They usually keep about two draftsmen but have most of their drawings made elsewhere. They rivet with air with a capacity of six hundred feet per second, the compressors being run by one seventy-five H. P. motor and one thirty H. P. motor.

STUPP BROS. BRIDGE COMPANY, ST. LOUIS, MO.

Stupp Brothers have a main shop about seventy-five feet wide by two hundred feet long with a lean-to on one side thirty feet by one hundred feet. They have seven punches with shearing attachments, one angle shear and two slow cut saws. Their capacity is about three hundred fifty tons per month, and a stock of about 1000 tons is carried on hand. They are equipped mostly for highway bridge work and do not do much building work. One interesting feature about this shop is its method of heating. The condensed steam is brought from the engine to the main shop where it is circulated through coils. Air being forced through these coils is heated to a temperature of about fifty-five degrees and keeps the whole shop at this even temperature during the coldest weather. They generate their own power by a one hundred twenty-five H. P. dynamo.

KOKEN IRON WORKS, ST. LOUIS, MO.

The Koken Iron Works have a main structural shop about seventy-five by one hundred twenty-five feet. Their capacity is about eight hundred tons per month and a stock of 3000 tons

is kept on hand. The shop equipment consists of four punches and shears, one angle shear and one Pels shear.

BANNER IRON WORKS, ST. LOUIS, MO.

The Banner Iron Works has a shop seventy-five feet wide by seventy-five feet long and keep a stock of eight hundred tons on hand. It has a capacity of about three hundred tons per month. The equipment is one universal shear and one slow cut saw. The shop is used mostly for foundry purposes.

KANSAS CITY WIRE AND IRON WORKS, KANSAS CITY, MO.

This shop is about eighty feet wide by three hundred fifty feet long. Its equipment consists of two universal punches and two high speed saws. It keeps a stock of about 1000 tons on hand and has a shop capacity of about four hundred tons per month.

BARTLETT STEEL COMPANY, KANSAS CITY, MO.

This shop keeps a stock of about three hundred tons, and has a capacity of about fifty tons per month. Its equipment consists of two universal punches.

Most of the shops visited use the slow cut saw for cutting off the beams. At one plant where a high speed saw was used the beams to be cut off were laid flat on their side on an iron bearing and prevented from moving away from the saw by an iron projection. The saw was about three feet in diameter and the edge appeared as though it had been punched, the cutting edge being the half of a 9-16 inch diameter hole. These saws were mounted on bearings, with a driving pulley connected to the driving wheel of a steam engine located about twenty feet distant.

Another shop used a high speed friction saw of sixty revolutions per second. The saw was mounted firmly and the beams could be clamped rigidly in place either on the side or on the edge to be sawed. The power was furnished by a thirty H. P. motor. Running water on the cutting edge of the saw kept it from getting hot.

In another shop where the high speed saw was used it was mounted and fixed between rigid bearings. The beam to be cut was laid on a table with a vertical extension at the back to hold the beam in place as it was forced against the saw by hydraulic power. In this case it was necessary for one man to place himself directly in front of the saw and with his head barely a foot from its cutting edge to hold the beam in position until the saw had started into the metal. A seventy-five H. P. motor was used to operate the saw while a thirty H. P. motor was used in the previous case where the beam was clamped and the saw fed against it.

In another plant there was in addition to the slow cut saw a Pels beam shear, but it was noticed that it was not in operation. On inquiry the writer learned that only when there were a large number of beams of the same size, especially up to eight or nine-inch, was the Pels shear economical to use. With these sizes the beam could be sheared by one stroke while with the heavier beams it is necessary to turn them over several times in shearing. When there were only a few beams of different sections to be cut the slow speed saw was used in preference to the Pels shear.

Most of the shops visited had angle shears to cut angles at any bevel, and arranged with attachments to cut channels up to seven inches.

At one plant the motor and saw were mounted on a carriage, the latter being moved forward and the saw fed against the beam by hydraulic power. The beam was clamped to an iron platform.

In most of the shops visited heavy milling machinery of up-to-date type was in use. One shop made its own milling machine which gave extra good service. Another shop which recently took a large order did all its milling by a coarse emery wheel, the wheel wearing for several months.

Where no loading cranes were used many different plans were in use. One shop used a guyed derrick which could load on any side, being quickly operated by wire cables.

At some places the loading was mostly done inside of the shop by the air hoists. One quick and cheap method of loading beams was to place the car to be loaded at a level so that its top connected with the punches. After the beams were punched they were moved forward on greased rails and the connection angle riveted on, and the coping done. They were then slid on by hand, into the car. Sometimes a horse was used to help in loading by which means a large number of beams could with a pulley and rope be pulled into car. One of the objections to this method of loading is that often the beams in falling the three feet or so into the car have their connection angles broken or bent.

At one plant a guyed derrick with a mast and horizontal arm was used to unload material. An electric hoist with the arm as a runway handled all the material. At another shop a derrick similar to the above was used with the exception that built up stiff legs were used to hold the top of the mast, in place of cables. The stiff legs were so placed that the horizontal boom could swing in a circle. An electric hoist was used to unload stock material. The mast was mounted on ball bearings and the boom could be swung around by rope tag lines.

At another plant having a full working capacity of 1000 tons per month, a sixty foot ten-ton electrical mounted gantry crane was arranged to run the full length of the stock year, being used to unload the material and also to pick it up and carry to the shop as needed.

MINERAL PRODUCTION IN IOWA FOR 1906*

BY S. W. BEYER.

The mineral production for 1906 totals considerably over a million dollars more than for 1905. The principal gain is in the value of the coal output which shows not only an increased tonnage but also an increase in price for the year. The production of sand and gravel is included in mineral production for the first time in a report of the Iowa Geological Survey. As in the case of quarry products it is almost impossible to secure accurate figures on account of the large number of small operators who produce only for their own use. The aggregate output is undoubtedly much greater than the figures show.

COAL.

The production of coal for 1906 shows a healthy growth in the industry for the year. This growth represents more than simply increased tonnage. Many of the larger companies installed during the year betterments in the surface equipment and mechanical haulage underground. The Consolidation Coal Company of Monroe County has in addition installed coal cutting machinery, greatly increasing the efficiency of the plants.

The subjoined table shows the growth in tonnage, value, average price per ton, average number of days worked and the average number of men employed during the past eight years, according to the authority of the U. S. Geological Survey:

Year	Total Tons	Value	Average Price	Average Number of Days Worked	Average Number of Men Employed
1899	5,177,479	$ 6,397,338	$1.24	229	10,971
1900	5,202,939	7,155,341	1.38	228	11,608
1901	5,617,499	7,822,805	1.39	218	12,653
1902	5,904,766	8,660,287	1.47	227	12,434
1903	6,365,233	10,439,139	1.64	232	13,583
1904	6,507,655	10,439,496	1.60	213	15,373
1905	6,798,609	10,586,381	1.56	209	15,113
1906	7,266,224	11,619,455	1.60	224	15,260

*The policy of co-operation practiced during the past ten years between the Federal and State Surveys was materially modified for 1906. All, or practically all of the correspondence was carried on from the central office at Washington. A list of the producers who could not be called up by letter, was furnished the local office, and those, as far as practicable, were visited by a representative of the State Survey. Tabulation sheet were supplied by the U. S. Geological Survey for coal, clay, stone, gypsum, mineral paints, sand-lime brick and sand and gravel. The Statistics for lead and zinc, cement products, and iron ore were collected and compiled by the local office. It is a matter of regret that the data supplied will not permit tabulation by counties for all of the mineral products.

A comparison of detailed statistical figures for 1906 with these for 1905 will render it apparent that of the leading coal producing counties. Appanoose. Jasper. Marion. Monroe. Polk and Wapello show good increases while Boone. Mahaska. Wayne and Webster show a decline. Keokuk and Lucas have dropped out of the list of large producers. Considerable exploratory work has been done in the latter county during the past few years with encouraging results and it may be confidently predicted that Lucas will regain its place with the large producers in the near future.

According to the authority of the U. S. Geological Survey. Iowa ranked ninth in production and eighth in value of the bituminous coal output for 1905. The ten leading producers for the year were as follows.

	State	Tonnage	Value.
1.	Pennsylvania	118,413,637	$113,390,507
2.	Illinois	38,434,363	40,577,592
3.	West Virginia	37,791,580	32,341,790
4.	Ohio	25,552,950	26,486,740
5.	Indiana	11,895,252	12,492,255
6.	Alabama	11,866,069	14,387,721
7.	Colorado	8,826,429	10,810,978
8.	Kentucky	8,432,523	8,385,232
9.	Iowa	6,798,609	10 586,381
10.	Kansas	6,423,979	9,350,542

The outlook for 1907 is for a continuance of the high price per ton with possibly a slight decrease in output.

CLAY.

Iowa clay products sold during the year 1906 were distributed as follows:

	Thousands	Value
Common brick	169,771	$1,125,009
Vitrified paving brick	16,930	185,990
Front brick	8,871	101,795
Fire brick	57	930
Drain tile		1,721,614
Sewer pipe		114,241
Hollow building tile or block		162,664
Miscellaneous		5,084
Total		$3,417,327

Pottery		
Red earthen ware	$10,100	
Stone ware	44,500	
Miscellaneous	3,400	
		$58,000

Clay Mined	Tons	Value
Fire clay	355	$ 560
Miscellaneous	1650	1350
		$1,910

The state still maintains her lead in the manufacture of drain tile, Indiana and Ohio being her closest competitors.

STONE.

The value of stone produced for 1906 shows a slight increase over the preceding year. The output was distributed as follows:

Limestone:		
Rough building	$105,203	
Dressed building	31,350	
Paving	6,527	
Curbing	8,030	
Flagging	7,632	
Rubble	84,553	
Riprap	35,810	
Crushed stone:		
Road making	38,189	
Railroad ballast	26,268	
Concrete	142,124	
Miscellaneous	8,129	
Lime burned	78,366	
		$572,181
Sandstone		5,601
Total		$577,782

GYPSUM.

The total production shows a slight decline when compared with the preceding year. Two new plants were built but were not put in operation until early in 1907. The statistics of the industry for the year 1906 are as follows:

	Tons.	Valued at
Quantity crude gypsum mined	286,857	$199,222
Distributed as follows:		
Sold crude,		
To Portland cement mills	8,390	11,973
As land plaster	3,751	6,922
Miscellaneous uses	1,472	3,441
Sold as plaster-of-Paris, wall plaster, etc	146,526	551,162
	160,139	$573,498

SAND AND GRAVEL.

The Survey publishes for the first time since its organization statistics of production for sand and gravel. Of necessity, reports could be secured only from the commercial pits. The

pit products may be classified as follows, calculated in short tons:

	Quantity	Value
Molding sand	4,952	$ 5,152
Building sand	127,271	45,158
Fire sand	1,800	1,400
Engine sand	8,550	2,100
Other sand	14,975	4,863
Gravel	27,125	15,707
Total	184,673	$74,380

LEAD AND ZINC.

Mining and exploratory operations were carried on with more than the usual vigor during the year in the Dubuque region. This was largely due to the greater demand for both lead and zinc. The price of lead ore reached $42.50 per thousand during the year, the highest in more than a third of a century.

LEAD.

About 600,000 pounds of lead ore were produced in Iowa during the year and were sold at an average price of $33.00 per thousand pounds. The price at the end of the year was on the advance and a consequent increase in output for 1907 is expected.

ZINC.

For a number of years no zinc ore has been marketed from the Dubuque region. The year 1906 marks the rejuvenation of the industry. About 500 tons of "dry bone" were sold at an average of $13.00 per ton. While no "jack" was shipped a considerable quantity of the disseminated zinc sulphide ore was mined and is now held in stock ready to be milled. A fifty ton mill is now in process of construction by the Avenue Top Mining Company and will be ready for operation September first, 1907. The mill is so arranged that its capacity can be doubled easily. It is reported that the Superior Mining Company contemplates building a mill in the near future.

Several companies have discovered and are now opening up extensive ore bodies and are only awaiting better facilities for cleaning and handling the output before mining on a large scale is undertaken. The outlook for the immediate future of the district is brighter than for many years and a greatly increased output for 1907 may be predicted with confidence.

SUMMARY OF PRODUCTION FOR 1906.

Lead (galena) 600,000 pounds	$19,800
Zinc (dry bone) 500 tons	6,500
Total	$26,300

IRON.

Iowa marketed no iron ore during the year 1906. The year was not, however, without results as to the future of the iron industry in the state. The Missouri Iron Company with headquarters in St. Louis has for more than eighteen months been exploring Iron Hill near Waukon in Allamakee County and neighboring well known iron ore bodies with the result that they are at the present time installing a modern washer to handle six hundred tons of finished ore per day. The plant will be supplied with power by a 400 horse power gas producer engine direct connected to D. C. generators and all crushers and other machinery will be direct connected to motors. It is believed that by washing, jigging and roasting, the metallic iron content of the ore can be brought up to between 55 and 60 per cent. The ore will probably be shipped by rail to the river and then by boat to Saint Louis for reduction.

MINERAL WATER.

The bottling and shipping of mineral water has become an established industry in Iowa. The most important producers are the wells at Colfax in Jasper county. The amount sold in 1906 was 227,500 gallons valued at $23,700 or at an average price of eleven cents per gallon. It was distributed as follows:

Medicinal water	$23,150
Table water	550
	$23,700

PORTLAND CEMENT.

The year 1906 was important in the history of the development of the mineral resources of the state in the fact that two Portland cement companies were organized and commenced the building of plants at Mason City and Des Moines, respectively. The former plant will reach completion on or about November 1, 1907. The Des Moines plant will not be in operation before the middle of 1908. A third company has been organized recently and is planning to erect a plant at Harvey, in Marion County.

CEMENT PRODUCTS.

The increase in the use of Portland cement is little less than phenomenal. The manufacture of cement products has become a recognized industry in a large proportion of the towns of the

state, especially throughout the north central portion, where structural materials are scarce. The principal products are building blocks, cement brick and drain tile. The industry is yet in its infancy. The leading products marketed during the year are as follows:

Building block	$207,195
Cement brick	24,379
Drain tile	102,535
Fence posts	11,497
Roof tile	5,215
Total	$350,821

A much larger amount of cement was used in the building of side walks, floors, foundations, chimneys, water tanks and fire proofing.

IN THE FOLLOWING TABLES IS SUMMARIZED THE VALUE OF MINERAL PRODUCTION FOR THE PAST THREE YEARS.

1904.

Coal	$10,439,496
Clay	3,487,376
Stone	542,170
Gypsum	469,432
Lead	2,619
Sand-lime brick	13,907
Total	$14,955,000

1905.

Coal	$10,495,593
Clay	3,408,547
Stone	533,509
Gypsum	589,055
Lead	1,500
Sand-lime brick	38,642
*Mineral water	36,200
Total	$15,103,046

1906.

Coal	$11,619,455
Clay	3,477,237
Stone, including lime	577,782
Gypsum	573,498
Lead and zinc	26,300
Sand-lime brick	38,255
*Mineral water	27,540
Sand and Gravel	74,380
Total	$16,414,447

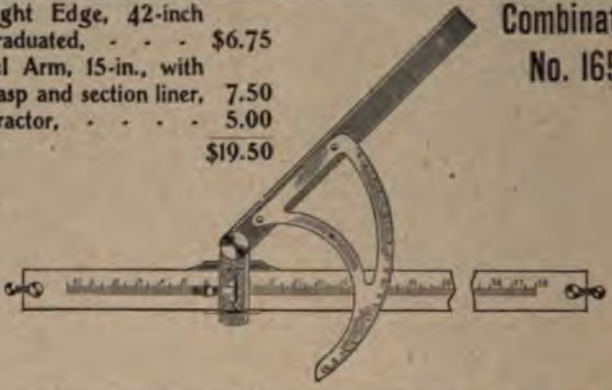
*Mineral paint is combined with mineral water.

STARRETT'S

Draughting Instruments

Straight Edge, 42-inch graduated, - - - $6.75
Bevel Arm, 15-in., with clasp and section liner, 7.50
Protractor, - - - - 5.00
$19.50

Combination No. 165½



THIS COMBINATION OF TOOLS WILL BE FOUND TO BE A GREAT AID TO BETTER AND EASIER DRAUGHTING. The Straight Edge has needle carriers at each end, swinging on taper studs. These may be swung to bring the points close to the working edge, and by a slight turn of a knurled nut may be rigidly locked, holding the straight edge bradded to the paper. We make these straight edges in six lengths, from 18 to 48 inches and either plain or graduated.

The Bevel Arms, with clasp and section liner, are made in 15, 24 and 36-inch lengths, and may be used with our graduated T-squares as well as with the straight edges.

The Section Liner is in the form of a knuckle joint and feeds either way against the graduation marks. By thumb pressure on the button-headed screw, which may be adjusted to fine or coarse movement, hatching may be rapidly and neatly done, and for accurately spacing work to the scale of 1-16, 1-8 or 1-4 to the foot, the device is a great convenience.

The protractor is 1-4 of 14-inch circle and is graduated to quarter degrees. It accurately fits the the bevel arm either side up.

Further information with prices of the various sizes of these instruments, is given on pp. 162 et seq. of our Catalogue No. 17AC of Fine Mechanical Tools. The Catalogue is free.

The L. S. Starrett Co.

ATHOL, MASSACHUSETTS, U. S. A.

Please Mention The Iowa Engineer when you write.

or could get permission to cross his neighbor's land. For this reason very little drainage was done prior to this time. Under the new law if a man's land is so situated that he has no outlet of his own, he can secure drainage by filing with the county Board of Supervisors, a petition for the establishment of a drainage district which includes all the lands tributary to the proposed improvements. Since this law came into operation, extensive improvements of this character are being projected Practically all the drainage of any magnitude in Iowa is being done in that portion of the state covered by the Wisconsin drift.

To arrive at a comprehensive idea of the extent of this drainage and the methods in use by practical engineers, the following list of questions was sent auditors and engineers in the counties included in this drainage area, and the data so collected compiled in the tables included in this report.

TILE DRAIN.

Maximum size used..................

Minimum grades used on large tile—

cement ....

Cost—large sizes—

clay ....

....

Please give information relative to a district drained by a large tile.

Name of district.................................

Acreage (wet land)....... Size outlet tile...... Grade ...... Total acreage in watershed........................

Is tile of proper size?..................................

(Replies relative to several districts will be appreciated.)

In designing tile systems do you use the College tables for acreage? ....

Do these tables give proper acreage for small tile........ and for large tile?.......... If not, by what factor can you multiply acreage as given for small tile?.................... and for large tile?..

Are cement tile satisfactory?..........................

Are cement tile made at a central plant or in the field? .... What advantages?......................

Do you use a broad, shallow ditch along side of tile as relief for heavy rainfall?..................................

Minimum depth recommended for tile laterals........with distance between lines..............and size..............

Any trouble with tile filling with mud or sand?..........

What precautions?.................................

....

Any trouble in heavy soil due to water not getting through to tile?............What precautions?......................

....

OPEN DITCHES.

Districts.

How many drainage districts in your county?............

How many drainage improvements in course of construction? ....

How many drainage improvements in course of survey?....

What is the approximate area of largest district?........

What is the approximate length of main ditch?..........

What is the maximum bottom width?.................

Designing.

What minimum grade is used in common practice?.......

What formulas or tables are used in calculating sizes of ditches? ....

....

....

In design of ditches what amount of water per acre per twenty-four hours do you figure on removing?...............

Have you seen ditches in operation so that you know from your personal observation that ditches designed as above noted are satisfactory?.......................................

Do the College tables for open ditches give proper results?

....

Construction.

What side slopes are used for ditches?.................

What types of ditching machines are used?.............

....

Is team work used and with what results?............

....

Give sketches showing cross sections of ditches made by the different machines, showing such cross section in each case at time of construction and as it now appears, stating time ditch has been constructed.

(Sketches)

Costs.

Give contract prices on recent work with estimated yardage.

....

Give data relative to one or more typical districts:

Name ....

Area............. Length of ditches.................

Estimated total cost.....................................

Cost of preliminary surveys.......... Other costs prior

to establishment......................................

....

Are damage claims usually allowed for land which is naturally wet?............ At what rate?......................

What is the everage maximum assessment per acre on slough land for open ditches?..................................

The consensus of opinion among the engineers seems to be that the tables for sizes of tile required, issued by the Civil Engineering Department of the Iowa State College are incorrect in that they require a larger tile for the drainage of various areas than practice seems to justify. In view of this fact, the accompanying table for size of tile required has been prepared

ACRES DRAINED BY TILE

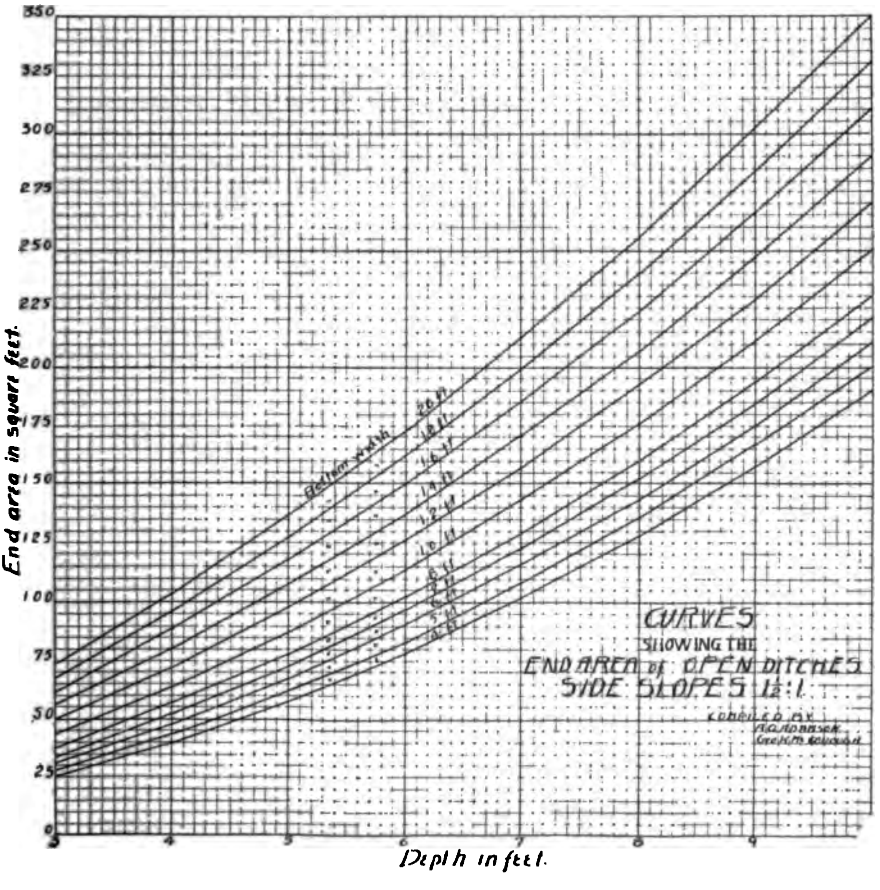
COMPILED FROM EXPERIENCE OF IOWA DRAINAGE ENGINEEES

GRADE IN FEET PER 100 FEET

Diam Tile	.04	.06	.08	.10	.15	.20	.25	.30	.40	.50
4"	4	5	6	7	9	11	12	13	15	18
5	9	11	13	14	17	21	24	27	30	40
6	13	17	21	23	28	33	36	40	45	55
7	20	25	30	33	42	50	56	60	65	75
8	30	40	48	55	62	71	80	90	100	140
10	65	80	96	120	140	160	180	200	250	320
12	100	130	160	188	240	280	325	360	400	480
14	190	240	288	320	390	450	512	556	646	750
15	240	320	342	380	466	540	600	660	765	880
16	354	420	496	576	700	800	900	1050	1200	1400
18	480	590	700	790	930	1100	1250	1365	1580	1800
20	660	810	940	1050	1280	1480	1660	1820	2100	2500
22	880	1050	1270	1400	1660	1950	2160	2360	2700	3100
24	1150	1470	1760	2100	2550	3000	3400	3800	4500	5000
26	1400	1700	2200	2700	3350	3860	4320	4740	6000	7200
28	1800	2200	2800	3400	4200	4900	5500	6000	7100	8000
30	2300	2900	3600	4200	5100	5800	6300	7100	8200	9300
32	2800	3500	4200	5000	6000	7100	8000	9000	11000	12800
34	3600	4400	5200	5900	7100	8300	9360	10400	12220	14000
36	4300	5300	6100	6700	8250	9800	10800	11960	13600	15200

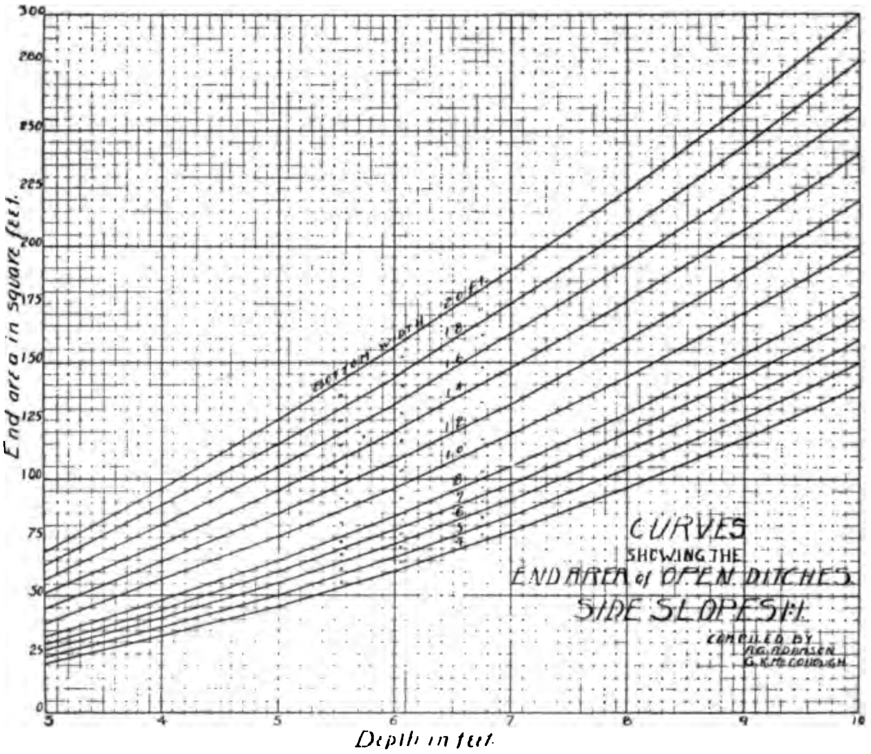
in accordance with the practice of various engineers. The areas here given are not determined by any mathematical formula, but give the approximate number of acres which will be drained by the different sizes of tile laid to the several grades, under ordinary conditions. However, local factors, such as the nature of the soil, slope of watershed, relative length and breadth of watershed often enter in to cause a considerable change in the size of tile necessary for adequate drainage.

For open ditches, it is recommended that the formula given by Elliot be used, which is $v = \sqrt{(a \div p) + (3 \div 2f,)}$ where v= velocity, a=area of waterway, p=wetted perimeter, and f=fall in feet per mile. Multiplying this velocity by the area of the waterway gives the discharge in cubic feet per second. This divided by .021, the factor representing the removal of the one-half inch of water per twenty-four hours, gives the number of acres which the proposed ditch will drain. This formula must also be varied in some cases to meet local conditions.



Several methods are in use among Iowa engineers for the preliminary survey of large drainage districts. A map, profile, and detail sheet of a typical tile drainage system located in Buena Vista County are herewith submitted, together with a report which it is necessary for the engineer to make to the county board of supervisors.* It is believed that the methods used in this survey are as practical and economical as the work will warrant.

Two curve sheets are also submitted which show the end areas of open ditches for various depths and bottom widths and for the side slopes of one on one and one and one-half on one. To find the cubical contents of a ditch the area for a given cut and size of ditch is taken from the curve. This is then multiplied by the distance between the stations which gives the contents in cubic feet. After the contents for the given number of stations is determined the sum is divided by twenty-seven which gives the contents in cubic yards.



For open ditch work a number of types of machines are being used. The dipper dredge boat seems to be the most com-

*This map and profile are not reproduced *for this article.*—Editor.

COUNTY	No. of Districts	Improvements Under constr.	Improvements Under Survey	Area in
Calhoun	50	12	5	19
Marshall	2	1		3
Clay	4			5
Palo Alto	30	3	15	9
Buena Vista	5	2	1	80
Humboldt	24	8	4	35
Emmet	26	3	4	6
Calhoun	64	8		20
Woodbury	2	1		50
Worth	5	3		4
Greene	18	3	11	5
Carroll	18	1	5	8
Pocahontas	24	6	60	100
Pottawatamie	2	2		9
Appanoose	2	2		7
Page	4			
Harrison	5	3	1	70
Mills	5	2	1	10
Wright	24	8	4	
Sac	10	3	3	12

COUNTY	Maximum Size Tile	MINIMUM 15"	MINIMUM 18"
Palo Alto	24"	.4%	
Buena Vista	16"		
Clay	24"		
Calhoun	24"		
Emmet		.06%	
Humboldt	24"	16" .1%	.08%
Carroll	15"	.06%	
Greene	32"	.2%	
Buchanan	24"	.05%	.04%
Van Buren	10"		
Warren			.22%
Sac	24"		

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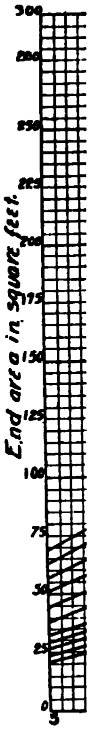

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mon but is open to the objection that no slope can be put on the ditch. The Austin-Jacobs machine digs a very good clean ditch but engineers who have seen it in operation claim it is not perfected sufficiently to give good satisfaction. The cost of using this machine is also much greater than the others. Team work for open ditches cannot be used to advantage unless the ground is very dry and then, unless the job is so small that a machine cannot be secured, the cost is excessive.

In all, drainage engineering has progressed rapidly in the last few years. It is a great work in Iowa and requires careful study to meet the many conditions arising in different cases. Much of the work has been done by men who have had no training or education along engineering lines and this has resulted in many cases in very costly work and poor results. More technically trained men are now taking up this work and it is to be hoped that results commensurate to the cost may be secured.

To the Honorable Board of Supervisors of Buena Vista County, Iowa:

Under authority of the appointment by you as engineer, to make survey examination, and report on the lands described in the petition for the establishment of a drainage district designated by your Board as Drainage District Number Eight of Buena Vista County, Iowa, I have to report that I have made a very complete survey and examination of the lands embraced within the watershed of the watercourse sought to be improved and I find that the construction of the covered drains hereinafter referred to will be conducive to the public health, convenience, and welfare and will be of public benefit and utility.

I attach hereto and make part hereof the commission executed to me under the aforesaid appointment, and the field notes showing the course and location of the main and lateral drains, the estimated cost of such main and lateral drains, and a schedule of all the lands which will be affected by the proposed improvement, together with the names of the owners thereof as determined by me from examination of the transfer books in the office of the county auditor.

I also return herewith a plat and profiles of the proposed improvement showing the course and location of the main and four lateral drains, also the wet and swamp lands affected by the proposed drain, and a detail sheet showing the details of the proposed construction.

FIELD NOTES

MAIN DRAIN: Starting at a point 395 feet E. and 540 feet S. of the center of the S. W. quarter of sec. 35 - 91 - 57, thence running S. 76—30′ E. 930 feet, thence S. 58 E. 620 feet, thence

E. on N. side highway 340 feet, thence N. 30 E. 180 feet, thence 22—30′ E. 855 feet, thence N. 66 E. 470 feet, thence S. 57 E. N. 16—30′ W. 1075 feet, thence N. 32 E. 430 feet, thence N. 9—30′ E. 1120 feet, thence N. 58—30′ E. 900 feet, thence N. 745 feet, thence N. 78 E. 610 feet, thence S. 49 E. 820 feet, thence S. 61—30′ E. 630 feet having its outlet at a point in the N. and S. quarter line of sec. 36—91—37, 325 feet S. of the center of the section.

To be constructed of 1920 feet of 18″ tile, 980 feet of 15″ tile, 5325 feet of 12″ tile, and 1550 feet of 10″ tile.

LATERAL NO. 1. Starting at a point in the corner of the fence at the N. E. corner of sec. 2—90—37, thence running E. on the S. side of the highway 280 feet, thence N. 7 W. 390 feet, thence N. 6 E. 860 feet, thence N. 31—30, E. 625 feet, thence N. 4—30′ W. 1315 feet, thence N. 16—30′ to its outlet at station 1920 of the main drain.

To be constructed of 920 feet 12″ tile, 280 feet of 10″ tile, and 2580 feet of 8″ tile.

LATERAL NO. 1-A. Starting at a point on the W. side of the highway 720 feet S. of the E. quarter corner of sec. 35—91—37, thence running N. 54 E. 1085 feet having its outlet at station 920 of Lateral No. 1.

To be constructed of 1085 feet of 8″ tile.

LATERAL NO. 1-B. Starting at a point on the W. side of the highway 510 feet S. of the E. 80 corner of the S. E. quarter of sec. 35—91—37, thence running N. 75—30′ E. 410 feet having its outlet at station 2685 of Lateral No. 1.

To be constructed of 410 feet of 8″ tile.

LATERAL NO. 2. Starting at a point on the W. side of the highway 175 feet N. of the E. 80 corner of the N. E. quarter of sec. 35—91—37, thence running S. 64—30′ E. 565 feet having its outlet at station 2855 of the main drain.

To be constructed of 565 feet of 8″ tile.

SPECIFICATIONS

All willow trees growing within 100 feet of this drain shall be grubbed out before the tile are put in place, especially those growing along the highway on the S. side of sec. 35, and those on the highway on the E. side of sec. 35.

Two brick catch basins, 3 feet inside diameter, shall be constructed, one to be placed on the E. side of the highway 180 feet S. of the E. 80 corner of the N. E. quarter of sec. 35, and the other to be placed on the N. side of the highway 330 feet E. of the S. quarter corner of sec. 35. These catch basins to be constructed according to plans filed herewith.* The brick shall be laid in cement mortar.

*These plans are omitted.—Ed.

The top of the catch basin shall be covered with a cast iron sewer manhole cover 3 feet 6 inches in diameter. The outlet tile of the catch basin shall be 6 inches in diameter and shall enter the catch basin at least 1 foot 6 inches above the bottom of the catch basin, and shall have a fall of at least 1 foot from the catch basin to the tile where it empties. These catch basins shall in no case be over 4 feet deep.

Seven broken stone or tile catch basins shall be constructed. One shall be placed on the E. side of the highway, and one on the W. side where lateral No. 1-A crosses the highway between sections 35 and 36. One to be placed on the E. side of the highway and one on the W. side where lateral No. 1-B crosses the highway between sections 35 and 36. One to be placed on the N. side of the highway and one on the S. side where lateral No. 1 crosses the highway between sections 36—91—37 and 2—90—37. One to be placed on the W. side of the highway where lateral No. 1 crosses the highway between sections 1 and 2. In building these catch basins the tile shall be covered with broken tile or broken stone to such a depth that when a 36-inch sewer pipe or tile is placed on end on the broken stone it will be just flush with the surface. The tile or stone shall be heaped up 6 or 8 inches above the surface of the ground.

At the outlet of the main tile a concrete retaining wall shall be constructed for the protection of the outlet. This retaining wall shall be made of concrete of the proportions, 1 of Portland cement, 3 of sand, and 6 of broken stone or gravel, and shall be built according to the plans filed herewith.

SCHEDULE SHOWING THE NUMBER OF ACRES IN THE WATERSHED AND THE OWNERSHIP

	Description.	Acres.	Owner.
rp. 91, R. 37.			
c. 26,	S. 10 A. of E. 60 A. of S.E. quarter	10	W. L. Geisinger.
	S. 10 A. of W. 100 A. of S.E. quarter	10	Mattie A. Foster.
c. 35,	N. one-half of N. E. quarter	60	Ira J. Frownfelter.
	S. one-half of N. E. quarter	70	N. C. Wheat.
	N. E. quarter of S. W. quarter	25	Geo. Steig.
	S. E. quarter of S. W. quarter	40	Sarah A. Keith.
	S. E. quarter	160	Geo. Steig.
c. 36,	N. W. quarter	130	Chas. S. Cutting.
	E. one-half of S. W. quarter	70	James Butler.
	N. W. quarter of S. W. quarter	40	Lizzie Butler.
	S. W. quarter of S. W. quarter	40	Anna Butler.
rp. 90, R. 37.			
c. 1,	N. W. quarter	50	Fred Schaller.
c. 2,	E. one-half of N. E. quarter	40	James Butler.
	W. one-half of N. E. quarter	30	R. J. Geisinger.
	E. one-half of N. W. quarter	20	Edward Turner.

I also recommend that the open ditch into which this system empties on the S. E. quarter of sec. 36—91—37 be cleaned out and deepened 1 foot for a distance of 400 feet from the N. and S. quarter line of sec. 36.

ESTIMATE OF COST

Main Drain—	
1920 feet of 18-inch tile at $3330.00 per M....	$ 633.60
980 feet of 15-inch tile at 230.00 per M..........	225.40
5325 feet of 12-inch tile at 110.00 per M..........	585.75
1550 feet of 10-inch tile at 86.00 per M..........	133.30
Digging and Refilling—	
Sec. 1 116.4 rods at $2.30 per rod................	267.72
Sec. 2 59.4 rods at 1.75 per rod................	103.95
Sec. 3 109.1 rods at 1.30 per rod................	141.83
Sec. 4 115.2 rods at 1.10 per rod................	126.72
Sec. 5 98.5 rods at 2.00 per rod................	197.00
Sec. 6 93.8 rods at 1.00 per rod................	93.80
Hauling 240 tons at $1.25 per ton..................	300.00
	$2809.07
Lateral No. 1—	
920 feet of 12-inch tile at $100.00 per M..........	$ 101.20
280 feet of 10-inch tile at 86.00 per M..........	24.08
2580 feet of 8-inch tile at 52.00 per M..........	134.16
Digging and Refilling—	
Sec. 7 55.8 rods at $1.60 per rod................	89.28
Sec. 8 17.0 rods at 0.75 per rod................	12.75
Sec. 9 84.8 rods at 1.25 per rod................	106.00
Sec. 10 71.5 rods at 1.10 per rod................	78.65
Hauling 42 tons at $1.25 per ton..................	52.50
	$ 598.62
Lateral No. 1-A.	
1085 feet of 8-inch tile at $52.00 per M..............	$ 56.42
Digging and refilling, sec. 11, 65.8 rods at $0.75......	49.35
Hauling 9 tons at $1.25 per ton....................	11.25
	$ 117.02
Lateral No. 1-B.	
410 feet of 8-inch tile at $52.00 per M................	$ 21.32
Digging and refilling, sec. 12, 24.8 rods at $1.10......	23.94
Hauling 4 tons at $1.25 per ton....................	5.00
	$ 53.60

Lateral No. 2—

565 feet of 8-inch tile at $52.00 per M	$ 29.38
Digging and refilling, sec. 13, 34.2 rods at $0.70	23.94
Hauling 5 tons at $1.25 per ton	6.25
	$ 59.57
Retaining wall at the outlet	$ 30.00
2 brick catch basins with connections at $10.00	20.00
7 broken stone catch basins at $2.00	14.00
Cleaning out old open ditch	20.00
Engineering and other contingent expenses, estimated	178.12
Total cost	$3900.00

Respectfully submitted this 25th day of April, 1907.

........................, Engineer.

THE NECESSITY OF TRAINED SUPERVISION IN BRIDGE AND CULVERT WORK*

BY SETH DEAN.

In opening a discussion of this subject, I will say that in my opinion good reasons for employing trained men may be found along several different lines, each of importance in proportion as the person's view point is near or remote to the subject. For instance, the party who is engaged solely in teaming and who travels the roads at all seasons of the year will be mainly interested in knowing that the bridge he crosses each day will safely carry the load that he wishes to haul over it and that there are no holes in the floor that may cripple his horses. If assured of these facts it matters very little to him who built the bridge or what it cost as he pays little or nothing towards its maintenance.

The taxpayer who perhaps lives in another part of the district and has occasion to use the bridge only at remote intervals, or perhaps not at all, will be mainly interested in knowing how much he was asked to contribute in taxes to its first cost, how long it will last without renewal, and whether the annual maintenance expense is as light on that kind of a structure as it would be on some other kind of material that would perhaps cost less or more in the first instance. If the bridge is one of considerable size and is located, we will say, on one of the leading streets of a city, the people living in the vicinity will insist that, in addition to a proper guarantee of safety, the structure shall be of a design somewhat in keeping with the buildings and

*An address delivered at the Good Roads School at Council Bluffs, Iowa, September, 1907.

properties in the neighborhood. For well they know that a prospective purchaser will take note of the character of such objects.

But from the view point of the civil engineer, the necessity is more in the fact that it will result in the making of better roads. The building of bridges and culverts better suited to the requirements of the situation, and whose life is prolonged by proper inspection and repair, results in a saving of money to the taxpayers; at the same time of course furnishing employment to more of their number. I take it for granted however that most of those present are more interested in the economy part of the subject so I will first take up that phase of the matter.

I believe very effective results can be secured, by proper organization with the forces we already have, and by using the materials to be found in most of the counties of the state. For maintenance purposes (and this will practically cover most of the work to be done) the county should be the unit and the Board of Supervisors, who are elected by the people at short intervals of time should represent their interests. This Board, which is now charged with the duty of providing the necessary funds by making the tax levy, should have general supervision of the work, should approve the contracts and decide on the final acceptance of the work after the contract is completed.

The working out of the details in the field, such as determining when and where, and the amount of work to be done, the kind and size of bridges and culverts and other waterways, should be under the direction of an engineer. The engineer should be selected by the Board and employed under contract by the year. He should be required to possess a certificate from some state board of examiners or a diploma from a recognized engineering school as a proof of his competency. He should furnish a bond running to the county as do othér county officers. A suitable office and the necessary assistants should be furnished. The engineer should have in his office complete records of the location of all the roads in the county. The width of the right of way, a record of the number and location of all bridges and culverts or other waterways, their length, kind of material used in their construction, and the cost, so far as he can get it, should also be kept on file. If he is located in one of the average counties of the state for size and mileage, he will have 1035 miles of road to look after. What proportion of this may be in bridges or waterways I do not know as no figures have ever come under my notice that would furnish a basis for even a rough guess. He will find however (according to the 1905 census) that his combined county and township road fund will be about $31,380.50 and the county bridge fund about $19,018.88 as resources to carry on his work. His county is already divided

into sixteen townships with 64.69 miles of road in each. This will be about enough mileage for one contract for a year.

The engineer should first divide his roads into three classes. In the first class are the roads that carry the most travel and receive the heaviest loads. These are generally the main roads leading into and between the market towns. The second class are the neighborhood roads that lead into, or connect as feeders to the first class roads. The third class roads are such as connect individual farms or that exist for school purposes alone.

It is of course not necessary for me to suggest that the heavier and better bridges should be put on the first class roads and those that have begun to show signs of weakness to be taken out or removed to the second or third class roads: and that wherever a concrete culvert can be economically substituted for an iron or wooden bridge it should be done. The culvert if properly built is the most durable, and being covered with a cushion of earth, makes a uniform road surface to drive over. Just where the limit of economy between concrete culverts and steel bridges lies is a matter to be determined for each locality. It depends very greatly on local conditions. No set rule that I know of will give the answer.

Having classified his roads, and from personal inspection estimated about what the cost will be of smoothing up and keeping in proper shape for the year those portions that do not require grading or new bridges, the engineer is ready to contract that portion of the work. On this point I have some rather radical ideas, since this work corresponds to that now done by the township officers. I would contract at a rate per mile for the roads to be kept in proper condition for a year. The contractor is to give a bond to the county as security for the completion of his work. Let him furnish his own tools as there is no very good reason for carrying a township tool account on the engineer's books. (A road drag or two, a few slip scrapers, and one or two plows and a few shovels will be enough tools. His work will be to drag and surface up the road, look after the side drainage, cut the weeds from the sides of the roads and trim the shade trees, (the farmers themselves must cut the hedges) and collect the township poll tax. A list of the polls in his district will be furnished him by the township clerk and he is to be charged with the amount as a part of his compensation. On a proper showing that for good reason any portion could not be collected, such sums are to be canceled at the time of final settlement at the end of the year. The contractor will get his pay monthly in county warrants on the road fund or engineer's monthly estimates filed with the auditor for the amount of work done.

On new construction, such as opening new roads or grading old ones, the work should be staked out by the engineer and the yardage calculated. Such work may be done by the county road gang under a foreman. For this class of work the county should furnish the tools, the engineer keeping an account of them. The men should be paid by the day for the time employed, or, if the work is heavy enough, it may be contracted by the cubic yard. In this class of work the secret of successful road building is in thoroughly compacting and solidifying the road-bed, and properly draining the water from the pits.

In bridge work it is generally economy for the county to buy the iron spans from reputable bridge companies on specifications of what is required at the place the bridge is to be used. Let the county bridge gang put them up. The bridge gang can also put in the culverts, the county buying the cement in car lots and the sand according to local circumstances. This crew works usually by the day, but if considerable cement work is required during the season it is fully as cheap to contract by the cubic yard. Cement work should be put in under proper supervision as much of the success of it lies in the proper mixing and placing of the materials.

I will say that, in general, there is no line of work within my knowledge where the proverbial "stitch in time saves nine" applies more forcibly than in the county road work. It is a common observation and remark that the gulches are getting deeper and the bridges longer each year. But is it really necessary that they do so? It seems to me that in most cases this can be prevented by a little care in side draining the water that collects in the wheel tracks on the hill sides, and investing a few dollars in protective work before the damage has been done. The engineer will be on the lookout for these places as he goes over the road on his inspection trips and will apply the remedy.

The engineer should keep in close touch with the county Board and make reports of the amount of work done by the various contractors monthly in order that the Board may know how the financial part is coming out, and whether the contractors are meeting the requirements. At the end of the year he should file with the auditor a report of the year's work, the amount of money expended for the maintenance of the road bed, the amount of grading done and the amount paid out for bridges. This report should include estimates of the work required for the next year.

Under this system it would be possible to tell at any time where the money was being spent and whether the work in one township was costing more proportionately than in another.

There would also appear in time a sort of rivalry or personal pride among the different contractors as to who was maintaining the neatest and best road district in the county. This spirit might be further encouraged by the offer of a substantial premium for high class work.

Now, I venture I hear some one say, where are the men to come from to fill the office of county engineer if we adopt the plan? The answer is simple. The law makers of the state several years ago foresaw the need of trained engineers and they have endowed and equipped the State College and the State University with a corps of the best instructors that can be had. In addition they have furnished at state expense laboratories and testing rooms and machinery for the use and instruction of students. These young men go into partnership, as it were, with the state, and give four years of their time gratuitously to secure the knowledge that is required for the work I have outlined above. After having been educated, largely at state expense, for the management of public work, is it the part of wisdom to permit them to find employment with private companies or to fill public positions in other states when we are needing just such talent in every county in this state to design and manage our public works? I think there can be but one answer to the question and that it will be but a short time until the taxpayers realize the advantage of proper supervision and insist on the change from the present plan of keeping our public roads in repair.

WORK OF THE ILLINOIS HIGHWAY COMMISSION*

BY A. N. JOHNSON, STATE ENGINEER.

What does it cost the taxpayers a year for roads and bridges under the present system? What are the results which the present system gives? These form two most important questions to inquire into.

A summary of the road expenditures of the State of Illinois shows that in 1905 the total cost of maintaining the 94,141 miles of public highways, including both money and labor tax, was $4,625,365, of which $490,563 is the estimated value of the labor tax, leaving $4,134,802 as the actual cash tax raised. Of this amount $1,888,730 were for bridges.

Through the aid of the 26,000 rural letter carriers of the State, exact information covering over a third of the roads in the State has been secured. Concisely, the summary of this information is that most of the roads are bad many weeks each

*An address before the Good Roads School at Council Bluffs, Iowa, Sept., 1907.

year. Much of the work is done at the wrong season, and the system is an extravagant one.

How much are the roads used? How many vehicles pass over a given road? The value of a road like anything else is determined by the amount of use that is made of it. If it is found that two different roads are put to the same amount of use, that is, carry the same amount of traffic, and these roads are situated in different communities, in one of which it is found economical and an advantage to the community to spend $5,000 a mile for construction, it is in general fair to assume that it would be worth while for the second community to spend about the same amount on its roads which have an equal amount of travel.

For the first time in this country a systematic census of road traffic has been undertaken and an actual count of vehicles passing at seventy-one points in different parts of the state is made three or four times a month throughout the year. The results of this census will show, among other things, exactly how the condition of the road affects its use.

In addition these data bring out very clearly the importance of good road conditions to the business interests of the smaller cities. For example, it is found that the traffic over earth roads is five to seven times as much when the roads are in good condition as during January, February and March; while the increase in the traffic in good weather where the roads are in good condition the year round, is only doubled, and in some instances observed the amount of traffic was remarkably uniform throughout the year. This latter condition was noticed particularly where there are large dairy interests.

One curious point was brought out during this investigation. Ordinary business interests and farming pursuits do not compare with the seductive attractions of a circus in stimulating travel on country roads. A circus will increase the number of vehicles four or five times over what would ordinarily be expected.

One of the first problems to demand the attention of the Commission was the proper maintenance of earth roads. The earth road drag is the simplest and, at the same time, one of the best means for caring for earth roads. When the Commission began its work, considerable had been heard about the drag but its use was not at all common. Special effort was made to bring to the attention of all the local highway commissioners and everyone interested in the improvement of the mud roads, the great benefits that could be secured by this very inexpensive method. Twenty-five thousand copies of a bulletin describing how to make the drag and exactly how to use it were distributed

in all parts of the state, and before summer opened it was reported there were no less than four thousand drags in use.

During the past winter special emphasis was laid on this method of road maintenance at the Farmers Institutes until at present there are few communities where drags have not been used, and in some townships that have been inspected over eighty per cent of the roads have been dragged.

At Galva, Henry County, perhaps the most systematic work has been done through the Galva Good Roads Association. They undertook over a year ago the maintenance of roads leading into Galva, and today these are among the very best earth roads to be found anywhere in the state. This Association has carried on the work systematically and aroused the necessary interest and impetus to keep the work going.

The convict labor law of Illinois which provides that the Board of Prison Industries of the state shall furnish to the State Highway Commission crushed rock for free distribution among local road officials is attracting much attention from road authorities all over the country. There has been for some time a general feeling that the convicts could be employed on public works, such as road building, and a practical solution of how to accomplish this has been undertaken in different states. But of all methods so far tried that provided by the 44th General Assembly seems to combine all the best features with fewest of the undesirable of any plan that has been proposed so far.

The primary object of keeping the convicts busy at some useful employment is accomplished without any interference with outside labor, in fact, making an increased demand for free labor that would not otherwise exist. There is no trespassing on the field of any existing industry. On the contrary, the state is creating an industry from the fact that the crushed rock is used in places where it has not been used before, or at any rate would not be used at all were it not practicable to get it at the reasonable rates made possible by this plan of co-operation.

There are at the present three crushers in operation, one at the Joliet penitentiary in the northern part of the state, and two at the southern penitentiary. The combined capacity of these crushers is 1,350 cubic yards per eight hours.

These crushers are operated by convict labor as are also the quarries. From four hundred to six hundred convicts can be successfully employed, depending on the extent to which the quarries have been opened. The prisons have sold enough of the crushed stone in open market to pay for the installation of the machinery so that this product is absolutely without additional cost to the tax payers of the state. This plan seems the most equitable arrangement that could be made for the conditions that exist in Illinois, where some sections of the state are

abundantly provided with road making materials and others have none at all.

With low freight rates and free material it is possible for those communities that do not have road materials, to get the crushed rock from the penitentiaries at a very low cost, and yet one portion of the state is not taxed for the benefit of another. The question of a large state aid appropriation, which is so bitterly opposed in many sections of Illinois, is met completely by this method of state co-operation.

It is perhaps too soon to predict how generally successful this plan will prove, but the past year's experience has been in every way satisfactory.

The successful distribution of this free crushed stone has been made possible by the low freight rates granted by the railroads of the state. The law provides that the Highway Commission shall be empowered to arrange for special freight rates. There has now been secured from all the railroads in the state a rate as low as one half cent per ton per mile, and from some roads a rate of three mills per ton mile. It is probable that as the work goes on and becomes more systematized, that still lower rates will be granted. The railroads in every instance recognized the importance of lending every assistance possible to this work, and, when assured that they would not be legally liable to grant to other shippers in the state the same rates named the highway commission, these specially low rates were readily obtained.

With the aid of the material thus prepared, the Commission has been able to construct experimental stone roads in sections of the state where macadam roads have never before been used or built, at a cost of little more than the expense of supervision. The Commission also furnishes the rollers and sprinklers, as few communities are at present provided with these necessities for proper stone road building.

In some instances the railroads were willing to accept ballast in payment of freight, and in this way the material was delivered to the local authorities free of charge and the only cost to the community for the road was the labor of preparing the road bed and putting on the material. Owing to the short time in which to prepare for work last season, but five experimental roads were built. Many applications have been made for this work, and already two roads are practically completed. The construction of eight or ten more will be undertaken this summer.

These roads are experimental in two ways; first, in that they demonstrate the physical possibility of making this kind of a road under given conditions; second, in an economic sense, in

that a community can better tell after making actual use of such a road whether it is worth while to construct more of this character. How else is this question to be intelligently decided by a community except by a practical trial?

As has already been stated, nearly half the cash tax for roads and bridges in 1905 was spent for bridges. In a number of counties sixty per cent of the amount spent for roads and bridges was for bridges, so that this feature of highway work is one of particular importance in Illinois. A casual investigation only was necessary to establish the fact however that a majority of the bridges were about half the requisite strength and many cost approximately twice what they should. The reason for this can be summed up as due to the lack of skilled supervision. It is not expected that commissioners and supervisors are engineers, yet they must expend the tax payer's money for bridges, about which they know nothing, nothing about the requisite strength, nothing about the proper cost.

To correct these conditions, the Illinois Highway Commission offers free of charge to the local highway officials, designs, estimates, and specifications for highway bridges of all kinds, and the demand for this aid indicates that it will be one of the most important phases of the work of the Commission. Already plans and estimates for some fifty bridges are under way. One instance is perhaps sufficient to show the practical importance of this work. In Geneseo township, Henry county, the amount appropriated by the local officials for four bridges was $30,000, about the price they expected to pay. Contracts were let for better and stronger bridges than had ever before been secured by this county, for $16,000.

Scarcely a township in the state but has very many small bridges with plank floors, and in many cases plank for the abutments, which are a source of constant danger to the traveling public and an endless expense to the taxpayers. It is within the means of every township to replace these small bridges, that is, bridges with spans to fifty feet, with concrete structures. Some townships may prefer or be able to build but one or two of these bridges a year, but the most economical plan would be to construct all at one time, making a systematic survey of the township sufficient to decide what size of bridge should go in at each place.

Money for the purpose would have to be raised by bonds, but this again would be in favor of the tax payers. These bonds could be issued and a sinking fund and interest provided for in most instances with the money that now goes to make and repair these small plank floor bridges. Inasmuch as the concrete structures which replace them are of such a permanent

character, it is entirely just and equitable that part of the burden of the expense should be paid in the future.

The Highway Commission has made plans for many township bridges forty to forty-five feet long. These bridges are built with a flat top which admits of their use in level country where there would not be room for an arch. It is the constant endeavor of the commission to raise the standard of bridge construction and encourage the adoption of the most suitable and economical materials that a given condition requires. The demand for plans and specifications has greatly exceeded expectations, and it is apparent, liberal as the last legislature was in its appropriation to the Highway Commission, that it will be scarcely sufficient to give as much attention to this feature of the work as it demands. Requests are received from every section of the state, and it is a mere statement of facts to say that the benefits will repay many fold all money spent in this way.

The wide-spread interest taken in the work of highway improvement, and particularly in connection with the State Highway Commission, is shown by the fact that this past winter sixty-seven Farmers Institutes requested the Commission to furnish a speaker to discuss road improvement.

In the agricultural communities there is no better medium to disseminate information than the Farmers Institutes, which are splendidly organized in Illinois. By this means much of the misconception and unfounded prejudice against the Highway Commission have been entirely dispelled and a practical interest aroused on the subject of road improvement. In Illinois any plan of highway work which does not appeal to the common sense of the members of the Farmers Institutes is doomed to failure. For these reasons much time has been given to the Institute meetings, and the practical results already apparent show that it was time well spent.

The experience already gained in the past year's work, combined with that of other sections of the country, shows the importance and necessity of experimental road work. The objects attained by this work are to introduce to different communities approved methods of carrying on their present road work, and also to demonstrate the value of new and untried methods.

For example, experiments are under way for the construction, in a simple way, of earth roads in such a manner that they will be reasonably substantial and useful throughout the year. A short piece of road which was constructed a year ago gave very good results this past winter, sufficient to warrant undertaking such experiments on a much larger scale. The possibil-

ity of their success more than warrants all expense which the State Highway Commission will incur in carrying them out. It is too early at present to predict what the outcome will be. At any rate, no effort will be left untried which promises to transform at a small expense our sticky, muddy roads into something that will be comfortable for travel at all times of the year.

One reason for the importance of experimental work in various kinds of road building is the fact that there are communities in nearly every section of the state that are ready to make improved roads and desire to have present methods improved, if they only knew how to go about it and were assured as to results. It is only by a practical object lesson, or practical experiment, that this can be accomplished.

Highway bridges are to be found in every community and the importance of their proper design and economic construction has been too long neglected. The introduction of permanent reinforced concrete bridges will be urged in every instance where this form of design can be appropriately used.

In all discussions relating to road improvement, so far as it concerns the work of the State Highway Commission, it is to be borne in mind that the functions of any such Commission are chiefly educational. For years large sums have been expended on roads and bridges in this state without skilled supervision. Certain usages and traditions have grown up and in accordance with them road work, such as it is, has been carried on. If any specially skilled or ingenious road master has tried better methods and made some practical and successful experiments, they have been done only on a very small scale, and more than likely cease when he leaves office. At the most, only a very limited neighborhood knows of the benefit from such work.

There is, therefore, a large field of operation for a State Highway Commission in investigating and finding out what are the best methods to be used under certain conditions and, having found them out, making them known to everybody. Let it be known that every commissioner can, for the trouble of asking, get advice on all matters of road and bridge building; that in fact the Highway Commission is a bureau of practical road information based on the best and most up to date methods. What is needed for the present is to get better results without increased taxation, and it is on this one principal alone that the work of the State Highway Commission is based. Before better results can be obtained, better methods are necessary, and it is essential that the advantages of better methods be first demonstrated before increased expenditures are considered. Better roads are possible without increased taxes.

AN INVESTIGATION OF THE DEVELOPMENT OF THE WATER POWERS OF IOWA

BY W. L. FOSTER AND H. J. GOULD

In a state where coal is one of the great resources, and specially where the coal fields are as easy of access as in Iowa, it may appear at first thought that the question of water power is one of little importance. However, Iowa has rivers of fairly constant flow and of sufficient volume to warrant their use as power producers even where steam may be cheaply produced.

The first requisite of a water power is a head of water. To obtain this a dam is necessary unless a natural fall of water is available. The earliest dams were built of brush, logs and earth, affording but small heads and little storage so that in dry seasons the power was gone. Later, crib dams came to be the chief type used. These are essentially crib work of round or square timbers, notched and bolted together, cross braced and filled with stone. A puddle of earth or sheet piling backed with loose rock makes the dam water tight. The crown and slope are covered with planking. Steel may be used for this, especially as an apron. Masonry and concrete dams are still later developments and are not very common as yet. They are more expensive and foundations are harder to obtain. The reinforced concrete type is growing in favor and will no doubt be much used in the future.

Having a head of water, the task becomes one of transforming the stored up energy into power. Water wheels have been used almost entirely for this purpose. Formerly over- and under-shot wheels were employed, but now these are rarely used. They have many disadvantages: high velocity losses; larger amount of room required than for turbines; they must be enclosed to keep from freezing in winter; back-water causes wallowing; expensive gearing is required to raise the speed to industrial requirements; and with these wheels high heads are hard to utilize.

The first turbine was introduced in this country in 1834 by a Mr. Fourney and from it has evolved the present turbine of America. The "cradle of the American turbine" has been the testing flume at Holyoke, Massachusetts. At Holyoke the total available head is but seventeen feet and for this reason some authorities condemn the turbine as inefficient except for small heads, forty feet or less. Iowa affords no heads of water over thirteen feet and the American turbine is used almost exclusively. The turbine consists of a runner carrying a number of vanes against which the water strikes as it comes from the buckets of the guide ring which surround it. The guide and

runner buckets are of such shape as to cause the runner to rotate from the reaction of the water flowing through.

The Pelton or impulse turbine is used only with high heads. It was developed in the West and consists of a number of buckets on the circumference of a wheel against which the water impinges and causes rotation.

STORAGE AND REGULATING WORKS.

Comparatively, Iowa rivers do not have a large flow and, if continuous power is to be maintained it is necessary to have some storage to rely on. Many powers while in use during the day are able to utilize more water than is flowing in the stream by having stored the night and Sunday flow. Storage is accomplished by means of a high dam to keep sufficient backwater or, by the use of flashboards. The latter give two or three feet greater height and are found in about half the reported plants in Iowa.

More important, however, is the storage of the flood water to tide over the dry seasons. Lakes or reservoirs accomplish this. Lakes of sufficient size to equalize the flow are not found on any Iowa rivers. The development of water power in this state has not as yet been considered of sufficient importance to warrant the construction of reservoirs. Careful investigation would be necessary to decide whether the outlay would yield a sufficient return in increased power.

GENERAL TOPOGRAPHICAL AND GEOGRAPHICAL FEATURES.

The first notable feature concerning the water powers of Iowa is that the majority of those in use are in the northeastern part on streams flowing into the Mississippi. The powers in the Des Moines valley and along the Missouri river are few in number and, with a few exceptions, of minor importance. Before discussing the reasons for this relatively limited area where water powers have been developed, the essential features of a river that are favorable to power production will be mentioned. These are: Considerable fall, the more the better; absence of floods; stability of its course; must not carry much sediment; and above all must have a comparatively constant flow.

These requisites are most nearly approximated in the rivers of northeastern Iowa. Though not large, these rivers have a fairly constant flow, a good fall and usually keep within their banks, many of the channels being through solid rock for a large part of the course. Floods occur occasionally but the flood plains are narrow and little damage results to power plants.

The north central part of the state is in the Wisconsin drift area and here practically no water powers are found. The drainage of this area is not sufficiently advanced to afford any large or constant streams. The surface is flat and dotted with

ponds many of which dry up in the summer. Around the borders of this area, however, for example, the Raccoon river, are found many good water powers.

In the southern part of the state the drainage is well advanced and along the Des Moines this has gone so far as to almost base level large areas so that the streams are of practically no value for water power. The Missouri slope, which is in the same drift area, is also well drained. The streams of this section are seldom of sufficient size to be of value for power.

In our investigation we have collected such data as we were able from power users concerning the present condition of Iowa water powers. Return postals were sent to the postmasters of towns near streams of any size asking for names of water power owners. As addresses were received lists of questions were sent out. The powers were divided into used and unused and the questions asked pertained to the dam, head, wheels, use of power, constancy, etc., aiming to include only those that the average mill owner could answer.

A summary of the answers received from powers now in use shows as follows as to material employed in their construction. Crib, 34; stone, 4; timber, 3; brush, 2; concrete, 2. The last two are at Marshalltown and Iowa Falls, the former having been destroyed however since the report was sent in. The abutments sum up: stone, 19; crib, 10; concrete, 2; brush, 1; rock, 1. Few reported on the foundation. These show: rock, 12; piles, 2; clay, 1; slate, 1. The cost returns were so variable as to make their reliability questionable. The limits were $500 and $20,000, these being both crib dams, one of seven feet and the other thirteen feet head. The difference is due no doubt to lengths of dam, and the cost of materials and labor. The greater number by far report a cost of $2,000 to $4,000.

The heads available vary from five to thirteen feet. Twenty three out of forty-one use flashboards varying in height from eight inches to two feet. Fourteen out of thirty-seven report fishways, four of these conforming to Iowa game law specifications. Some seepage is reported in nearly every instance, showing that the building of a water tight dam is a rare feat of construction.

Repairs on wheels are reported light but on the dams vary from three dollars to $1,000 per annum, the latter being the only one above three hundred dollars. In order of number reported, the makes of wheels are, Leffel, McCormick, Fleniken, Victor and Rose. Nearly all are gear connected, belt and rope drive being used in a few instances only. Governors are reported by but seven plants. They are the Pritchard or Woodard Electric types. It is notable that draft tubes, which effect a consider-

TABLE NO. 2

THEORETICAL AND REPORTED H. P. OF IOWA WATER POW

1	2	3	4	5	6			7	8
					Wheels			Full Gate Opening	
Town	h	Area	10 Mo. flow cu. ft. Min	Theoretic'l H. P.	No.	Size	Make	Water used	H. P.
Alpha	9′	240	2160	29.5	2	36	Leffel	9660	131
					1	30	"	3560	49.1
					1	24	Fleniken	2094	28.8
Adel	11′	2010	18090	300	1	42	McCormick	7098	118
Amana	8′	2685	24150	293	4	48	Leffel	37324	456
	10′	2585	24150	366	3	48	"	31299	480
	12′	2685	24150	437	3	48	"	34287	630
Anamosa	7′	1830	16500	175	1	35	"	4260	45.6
					1	40	"	5587	59.8
					1	56	"	10950	117
					1	60	"	13419	144
Canton	12′	775	6970	127	3	30	"	12342	226.5
Cedar Rapids	6′	6320	56880	517					
Central City	7′	1440	12960	138	1	40	Leffel	5587	59.8
Chickasaw	8′	275	2475	30	2		McCormick		
Clermont	12′	915	8230	150	4				
Clarksville	6′	1790	16110	122	2	54		16898	116.4
					1	48		6298	57.1
Dakota City	8′	1250	11250	136	1	36	McCormick	4194	50.7
Dale	7′	330	2970	31.5	1	50	Leffel	8729	93.5
Davis City	6′	720	6480	59	1	30	"	2909	26.7
					1	36	"	3944	36.2
					1	40	"	5172	47.5
Decorah	12′	375	3370	61.5	1	30	"	4114	75.5
Decorah	10′	375	3370	51.	3	35	"	15273	199.5
Eldora	9′	805	7250	99	3		"		
Eldorado	9′	775	6970	95	2		"		
Elgin	8′	915	8230	100	1	32	"	3359	41.1
					1	40	"	5972	73.1
Frederika	8′	1440	12950	157	1	40	"	5972	73.1
					2	48	"	18662	228
Greene	8½′	1380	12400	160	1	40	"	6154	80.1
					1	30	Victor	3461	45.1
Hazelton	14′	170	1530	32.5	3	20		5880	124.5
					1	16		947	20.
Humboldt	13′	3230	2900	571	1	18		1336	26.2
					2	36	McCormick	10694	210
Iowa City	10′	3317	29900	453	2		Leffel		
Iowa Falls	10½′	665	5980	95	1	36	McCormick	4804	76.3
Iowa Falls	10′	665	5980	91	1	30		3756	57.5
					1	40		6677	102
Lime Spring	11′	150	1350	22.5	1	35	Leffel	3756	57.5
					1	40	"	13354	204
Littleton	9′	870	7830	107	3	42		19268	261.9

able saving in the case of low heads, are used in but nine instances.

Loss of time comes about from three causes, ice, low water and high water. Three plants only lost fifteen days each from ice. Four report a loss of a month or more from low water. Nearly all have trouble with high water, control of which is impossible in most of our capricious Iowa rivers.

The horse power is reported as varying from 1 1-2 to 340. The application of the water powers is as follows: milling, 33; electric lighting, 10; pumping, 2; creamery, 1; stone crusher, 1 Twenty out of forty-six report a steam plant to be used as needed where power must be had regularly, as in case of an electric light plant or an important mill.

Table No. 1 gives the gauging for the Des Moines, Iowa, Cedar and Wapsipinicon rivers. The minimum monthly flows are given for ten and twelve month periods for the years 1903 and 1904 only. The amounts vary considerably but we have taken as a fair figure for a twelve month's flow .07 cubic feet per second per square mile and for a ten month's flow .15 cubic feet. This amount will be obtained in all average years and but few exceptionally dry seasons will run below it.

TABLE I.

DISCHARGE OF IOWA RIVERS.*

River	Where Gauged	Minium Flow			
		12 months		10 months	
		1903	1904	1903	1904
Des Moines	Keosauqua	.15	.058	.25	.149
Iowa	Iowa City	.12	.066	.16	.080
Cedar	Cedar Rapids	.27	.133	.35	.152
Wapsipinicon	Stone City	.14	.078	.23 (?)	.096

Table No. 2 is a comparison of the horse power reported with that available in the stream considering the capacity of the wheels used. The area is in square miles and taken where possible from the reports of the United States Geological Survey. The others were obtained from the planimeter readings on a large scale map of the state. From Table No. 1 we have a minimum ten month's flow of .15 cu. ft. per second per square mile of drainage area. Column 4 is therefore obtained by multiplying Column 3 by .15 and then by 60 which gives the flow in cubic feet per minute. The theoretical horse power is computed thus: multiply the cubic feet of water by 62.5 and this result by the head in feet, giving foot-pounds; dividing by 33,000 gives the theoretical horse power for perfect wheels. If an efficiency of 80 per cent is assumed, multiplying by .80 gives the theoret-

*Water Supply and Irrigation Papers, U. S. Geological Survey, Nos. 99 and 130.

ical horse power which should be developed under average conditions.

Columns 7 and 8 give the water used and horse power obtained under full gate opening taken from the catalogues of the wheel makers. These figures are guaranteed to be from actual tests made at the Holyoke testing flume. It will be noted that the most of the plants have a larger capacity than is available in the stream. During the low water season therefore they cannot run at full power.

Table No. 3 is a summary of unused water power. Various reasons are assigned for the abandonment of these plants. In most instances lack of business probably accounts for the failure to keep the plant in repair. Columns 6 and 7 shows that as a rule they are now useless for power purposes without expensive repairs. The estimated horse power runs from ten to 1,500. The latter figure is no doubt too high but it is evident that much power is going to waste in the streams of the state. Few plants have been replaced with steam and nearly every report was favorable in comparison with steam.

THE DRAINAGE BASINS.

Des Moines river: Although the largest river in the state, the Des Moines is of but secondary importance in water power development. It rises in Minnesota, entering the state in Emmett County, and flows southeast to the Mississippi in Lee County. It has a length of three hundred seventy miles and a drainage area of 14,717 square miles. One important tributary alone, the Raccoon, drains 3,377 square miles. The upper portion of the basin includes many small lakes which tend to equalize the flow. Considering the large drainage area and the fairly uniform flow it would seem that the Des Moines should be a good stream for water powers. Exclusive of the Raccoon, however, there are but five developed water power plants. These are located at Ottumwa, Des Moines, Humboldt, Rutland and Dakota City.

The Raccoon joins the parent stream at Des Moines and has been developed for water power at numerous points. Those now in use are, Adel, Perry, Lake City, Redfield, Panora, Coon Rapids, Dale, and Guthrie Center. It is worthy of notice that these are all on or near the edge of the Wisconsin drift area. Along the lower portion of the Des Moines are several abandoned plants that were originally designed for the purpose of slack water navigation.

Skunk River: The Skunk river rises in Hamilton county and empties into the Mississippi between Des Moines and Lee counties. It is two hundred miles in length with a drainage area of 4,409 square miles. The valley of the stream is broad

TABLE No. 3—REPORT FROM IOWA WATER POWERS—UNUSED.

1 TOWN	2 COUNTY	3 River	4 Former Use	5 Why Abandoned	6 Present Condition	7 Cost to Restore	8 H. P.	9 Steam	10 Opinion
Algona	Kossuth	Des Moines	Milling	Mill burned	Could be used			None..	
Augusta	Lee	Skunk	Milling	Lack of power	Usable at low water			None..	Water better
Belmond	Wright	Iowa	Milling	Mill torn down	Used for ice pond				
Bentonsport	Van Buren	Des Moines		Washout					
Bonaparte	" "	" "		Washout					
Brighton	Washington	Skunk	Milling	Mill burned	Not usable		200	None..	Unfavorable
Centerville	Appanoose	Chariton		Expense of repairs	Nothing left				
Cherokee	Cherokee	Little Sioux							
Chester	Howard	Upper Iowa	Milling	Washout	Not usable	$ 800	40	84 H.P.	Water better
Clarksville	Butler	Cedar							
Coppack	Henry	Skunk							
Decorah	Winneshiek	Upper Iowa	Milling	Mill burned	Could be used		500	60 H.P.	
Delhi	Delaware	Maquoketa	Milling	Lack of wheat	Could be used		150	None..	Water better
Dubuque	Dubuque	Paint Creek	Milling	Could be used	Could be used		10	50 H.P.	Water better
Fayette	Fayette								
Ft. Dodge	Webster								
Fulton	Jackson	Maquoketa							
Estherville	Emmet	Des Moines							
Graham		Little Turkey	Milling	Washout	Not usable				
Grant City			Milling	Washout	Not usable	500	140	2 Engines	
Harlan	Shelby	Nishnabotna							
Harvey	Marion	Des Moines	Milling	Unprofitable	Not usable				
Janesville		Cedar	Milling	Washout	Not usable	8000	350	None..	Water better
Keosauqua	Van Buren	Des Moines	Milling	Washout	Could be used		200	35 H.P.	
Lamont									
Marble Rock	Floyd	Shellrock							
Marengo	Iowa	Iowa							
Milford									
Moscow	Muscatine	Cedar	Milling	Mill burned	Not usable				Water better
Osage	Mitchell	"	Milling	Mill burned	Not usable		75	None..	Unfavorable
Redfield	Dallas	Coon	Milling	Washout	Not usable			None..	Water better
Ridgeway	Winneshiek	Upper Iowa	Milling	Washout	Not usable	1500	60	None..	Water better
Rockford	Floyd	Lime Creek	Paper Mill	Mill burned		1500	60	None..	Questionable
Rockford	"	" "	Milling	Washout	Not usable	10000	75	None..	Water cheaper
Spillville	Winneshiek	Turkey	Milling	Mill burned	Could be used	2000	100	None..	
Union Mills	Mahaska								
Waterville		Paint Creek	Milling	Washout		3000	25		Water better
Waucoma	Fayette	Crane Creek	Cane Mill	No business	Not usable	2000	60	None..	Water better
Waucoma	"	Turkey	Milling	No business	Not usable		1500	None..	
Waubeek	Linn								
Webster City	Hamilton								
Wellman	Washington								

and flat and extremely liable to flood. At present it is utilized for power at but three points, viz., Lowell, Brighton and Oskaloosa. Many unused plants are found which indicate that the stream has not proved well suited to power development.

Iowa River: The Iowa River and its tributary the Cedar are by far the most important streams of the state so far as water power development is concerned. It rises in Hancock county and enters the Mississippi in Louisa county, measuring about two hundred fifteen miles in length. Its basin has an area of 12,412 square miles, 4,469 of which is tributary to it above its junction with the Cedar. Above the same point the Cedar river drains seven hundred fifty-nine square miles.

The Iowa, including its minor tributaries, is used for power at the following places. Riverside, Kalona, Iowa City, Amana, Tama, Marshalltown, Eldora, Steamboat Rock, Iowa Falls and Belmond. The Cedar with its branches is utilized for power at Cedar Rapids, Waterloo, Cedar Falls, Shellrock, Clarksville, Greene, Mason City, Northwood, Waverly, Nashua, Chickasaw, Charles City, Floyd and St. Ansgar. The largest number of plants for any one stream, and many of the best ones reported, are on the Iowa or Cedar and their tributaries. These rivers are favorable to a much more complete development of their water powers.

Wapsipinicon River: This river has a very narrow valley extending across the state from Mitchell to Scott County. It is about two hundred miles in length and has a drainage area of 2,304 square miles, of which 1,308 square miles are above Stone City where a gauging station is maintained. The river has a fairly constant flow although its headwaters sometimes become quite low. In many parts of its course it cuts through beds of limestone and sandstone which afford excellent sites for mills. Water power plants are reported at Toronto, Oxford Mills, Anamosa, Central City, Oelwein, Frederika and Littleton.

Maquoketa River: The Maquoketa river takes its rise in Fayette county and joins the Mississippi in Jackson county. It is about one hundred miles long and drains 1,874 square miles of territory. Water powers are found in use at this time at Maquoketa, Canton, Monticello, Hopkinton, Manchester and Fulton. But four abondoned powers are reported.

Turkey River: This stream rises in Howard and empties into the Mississippi in Clayton county. It is about ninety miles long and drains 3,450 square miles. No gaugings have been made but its value for power is shown by the fact that there are now along it eight plants in use; more in proportion to its length than on any other river in Iowa. These plants are located at Turkey River, Mederville, Elkader, Elgin, Clermont,

Eldorado, Spillville and Alpha. A few abondoned powers are found, especially on the upper portion of the river.

Upper Iowa River: The Upper Iowa river is a small stream running nearly parallel to the state line between Iowa and Minnesota and having a small basin of about eight hundred fifty square miles. But three plants are reported, viz., Decorah, Florenceville and Lime Spring.

Resume: We have found in use in Iowa sixty-nine water powers. They have been and are used mostly for milling, but the tendency is to construct the newer plants for electric lighting and pumping. The reports received show that water power has proved economical and satisfactory.

The number of abandoned plants indicates that there are many possible locations not occupied at present and chiefly because of a lack of a demand for the power. In many instances the unreliability of the streams in the dry season of the year is the drawback to the use of water power. Regulating works built in the upper portion of the river would equalize its flow and thus aid in obviating this difficulty.

Water power is an economical source of energy which in the streams of Iowa is largely latent and unused. Its utilization for the manifold operations to which it is applicable is to be advanced and encouraged.

ALUMNI

Mr. L. A. Wilson (I. S. C. '07) has been appointed state drainage engineer to have charge of the lake bed surveys. Mr. Wilson's headquarters are at Sibley, Iowa, where he is associated with Mr. Barber of the same class.

F. M. Okey (I. S. C. '04) received the appointment to the new position in Civil Engineering at his alma mater. Mr. Okey's time will be divided among class and field work and laboratory work for the Engineering Experiment Station.

R. W. Crum, a graduate in this year's class in Civil Engineering succeeds Mr. Berg as instructor in drawing.

C. C. Clausen, B. Min. E., '07, is chemical engineer with a large gas and coke manufacturing company at El Paso, Texas. S. S. Nichols, B. M. E., '05, is superintendent of this plant.

Paul B. Tracy, B. Min. E., '06, is assistant chemist with the Bingham Consolidated Mining Company, Utah. W. B. Cole of the same class is in Arizona representing the Western Development Company of Chicago.

H. M. Parks, a graduate in Mining Engineering, 1903, has accepted a position in the State College of Oregon at Corvallis. He has been an instructor in mineralogy in Northwestern Uni-

versity for the past two years and will have charge of the instruction in Mining Engineering in the Oregon school.

AT THE COLLEGE

Howard C. Ford is the new assistant professor of Irrigation Engineering at the College. Professor Ford is a graduate of the University of Colorado where he has been instructor in Civil Engineering for the past three years.

J. E. Kirkham of Pittsburgh succeeds Professor L. E. Ashbaugh as associate professor of Civil Engineering. Professor Kirkham has been with the American Bridge Company for several years, and consented to enter the teaching profession as offering him better facilities for preparing his book on "Structural Steel Work" on which he is now engaged.

Wm. Kunerth, a graduate (A. B.) from the University of Wisconsin, has been appointed instructor in the department of Physics.

H. A. McCune succeeds Mr. Marsh as instructor in the Physics and dynamo laboratories. Mr. McCune graduated from the Electrical Engineering department this year.

Mr. J. B. Varela takes the place in mechanical drawing formerly held by Martin Louis. Mr. Varela has taken a course in drafting in the Stevens Institute of Technology and has had six years practice with the Bethlehem Steel Company.

John T. Bates, a graduate of the University of Maine, comes as an additional assistant in the mechanics laboratory.

A. W. Cameron takes charge of the forge shops. Mr. Cameron has been in the machine shops at Oelwein but has had over twenty-five years experience in shops in the United States and Canada.

PERSONAL AND GENERAL

E. E. Bugbee, formerly Assistant Professor of mining at the Iowa State College has resigned his position as Professor of Mining Engineering in the University of Washington to become Assistant Professor of Metallurgy in the Massachusetts Institute of Technology.

Professor Lewis E. Young has been recently elected Director of the Missouri School of Mines and Metallurgy at Rolla, Mo. Professor Young comes to this new position from the Colorado School of Mines where he has been Professor of Mining since 1903. He is a graduate of the State College of Pennsylvania and was formerly Assistant Professor of mining engineering at the Iowa State College.

Professor L. E. Ashbaugh, formerly Associate Professor of Civil Engineering at Ames, is assistant engineer with the Colorado Water Company at Colorado Springs. W. D. Maxwell, C. E. '06, and Harry Gray, of the same class have recently entered the employ of this company.

H. C. White, formerly a student in mining engineering at the college has taken charge of the drill and compression department of the Jeffries Company of Columbus, Ohio, one of the largest manufacturers of mining machinery in the country.

The new Hearst Memorial building of the College of Mines of the University of California was dedicated August 23. Addresses were delivered by President Wheeler, Prof. J. G. Howard, T. A. Rickard and Prof. S. B. Christy, Dean of the College of Mines. We are reminded that this building is the first undertaken in connection with a university to be devoted alone to mining and metallurgy. The building was begun in 1901 and its completion gives the University of California rank among the first mining schools of the country.

CONVENTION DATES

The Iowa Brick and Tile Association will hold its 28th annual convention at Des Moines January 22 and 23. The program is not yet made public. Particulars may be had from the Secretary, C. B. Platt, Van Meter, Iowa.

The Iowa Engineer is the official organ of the Brick and Tile Association and all important papers read at the convention will appear in this publication.

The 4th Annual meeting of the National Association of Cement Users will be held at Buffalo, January 20 to 25, 1908.

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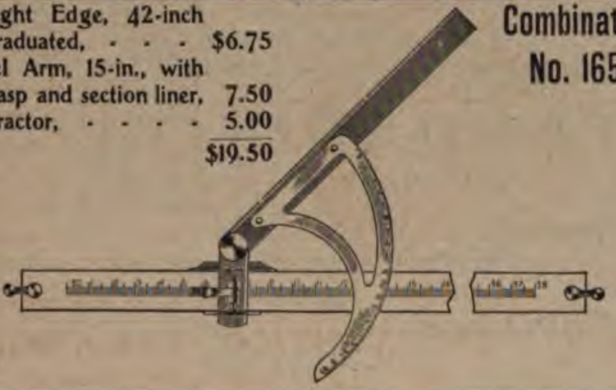
$19.50

Combination No. 165½



THIS COMBINATION OF TOOLS WILL BE FOUND TO BE A GREAT AID TO BETTER AND EASIER DRAUGHTING. The Straight Edge has needle carriers at each end, swinging on taper studs. These may be swung to bring the points close to the working edge, and by a slight turn of a knurled nut may be rigidly locked, holding the straight edge bradded to the paper. We make these straight edges in six lengths, from 18 to 48 inches and either plain or graduated.

The Bevel Arms, with clasp and section liner, are made in 15, 24 and 36-inch lengths, and may be used with our graduated T-squares as well as with the straight edges.

The Section Liner is in the form of a knuckle joint and feeds either way against the graduation marks. By thumb pressure on the button-headed screw, which may be adjusted to fine or coarse movement, hatching may be rapidly and neatly done, and for accurately spacing work to the scale of 1-16, 1-8 or 1-4 to the foot, the device is a great convenience.

The protractor is 1-4 of 14-inch circle and is graduated to quarter degrees. It accurately fits the the bevel arm either side up.

Further information with prices of the various sizes of these instruments, is given on pp. 162 et seq. of our Catalogue No. 17AC of Fine Mechanical Tools. The Catalogue is free.

The L. S. Starrett Co.

ATHOL, MASSACHUSETTS, U. S. A.

ating the engine. The gas as it leaves the producer is hot and dusty and may contain some tar. It is therefore passed through a scrubber, which is a closed steel cylinder filled with coke over which a quantity of water is sprayed. In this scrubber the foreign matter is removed and the coal gas passes on to the engine. Surrounding the upper part of the producer, or the gas pipe after it leaves the producer, is a water jacket, or vaporizer, as it is called. Water is fed to this and changed to steam by the heat of the gas. This steam is led down to the bottom of the producer below the grate and passes up through the fire with the air. The steam cools the fire to a certain extent, and thus reduces the formation of clinker, besides adding to the gas a considerable percentage of hydrogen, due to the decomposition of the steam. The air and steam may be forced through the fire by means of a blower, or it may be drawn through by the suction of the engine. The former is called a pressure producer, and the latter a suction producer.

The suction producer should have a fuel whose gas is comparatively free from tarry matter, as the apparatus for its removal would interfere with the free passage of the gas. Thus it is that only anthracite coal, charcoal and coke have been used to any extent in the suction producer. The pressure producer will handle most any non-caking coal or lignite, but the necessary apparatus for the removal of the tar or lampblack makes the producer more complicated.

The important constituents in the gas, in either case, are carbon monoxide (CO), hydrogen (H), and the light hydrocarbons ($C_x H_x$).

The suction producer, being more simple, is the one to be preferred in plants of three hundred horse-power or less. It is not only more simple, but both the initial cost and cost of operation are considerably lower for those sizes.

One of the first commercial plants in this state was installed at the little city of Algona about two years ago. This plant was of the suction type, and was installed for the purpose of furnishing electric current to the city and pumping water for the water system. The engine was of the vertical, throttling governor type, composed of three cylinders, and rated at one hundred fifty brake horse-power. The ignition was effected by means of mechanically operated electric igniters with adjusting levers for changing the point of ignition. In starting, the spark was obtained by means of an electric battery, but as soon as the engine was up to speed, it was switched over to an "Apple" sparking dynamo. The engine was started by means of compressed air in one cylinder, the air having been compressed into a tank by means of a small compressor run with a gasoline engine.

In every day operation, the engine was belted direct to a 75 K. W. alternating current generator which furnished current for city lights and for running an electrically driven air-compressor. This compressor furnished air for lifting water from a deep well for the water works.

The producer, as mentioned before, was of the suction type, and of sufficient size to accommodate the engine. The producer was five and three-quarters feet in diameter and eight feet high. The vaporizer was really a miniature tubular boiler through which the hot gas passed on its way to the scrubber. The scrubber was a cylindrical sheet-steel tank, four feet in diameter and twelve feet high, filled with coke. Water sprayed into the top trickled down over the coke and in meeting the gas coming from the bottom removed from it the dust and dirt which it contained.

This complete plant was installed by the Fairbanks Morse Co. of Beloit, Wisconsin, and as far as the author has been able to learn, was the first plant of its kind in the state at the time of its installation. On this account, it aroused considerable interest. Some time after its installation, a test of the plant was made by two seniors in Mechanical Engineering at the Iowa State College, Messrs. Wilkinson and Lungren, and it may be of interest to note the results.

Four brake load tests were made, and two tests with generator load. The brake was the ordinary pony brake, and was so adjusted as to give for the four tests, one-fourth, one-half, three-fourths, and full rated load, respectively. Anthracite pea coal was used throughout all the tests. Space will not permit of a detailed report of the tests, hence only the final results will be given here.

Table I is a summary of results obtained in the several tests.

TABLE I.

TEST OF PRODUCER GAS POWER PLANT. 150 B. H. P.

SUMMARY OF RESULTS.

Number of Run	I	II	III	IV	V	VI
Length of Run —Hours	6	7	6	6	14.083	12.5
Horse-Power Developed ...	40.13	82.52	156.95	113.27	38.86	63.2
Total Horse-Power Hours.	240.78	577.64	939.7	679.62	547.27	790
B. T. U. Devel'd in Work......	612782	1470086	2391524	1729623	1392795	2010539
B. T. U. per Lb. Dry Coal.....	10990	12880	13315	12990	———	———

B. T. U. per Lb. as fired.......	10740	12470	12905	12500	———	———
Lbs. Coal as fired.......	363.75	671	941	871.5	1404.75	1077
Total B. T. U. in Coal as fired..	3905300	8370300	12143500	10948400	17087200	13100400
Lbs. Ash.......	59.9	151.5	181.4	89.5	61.5	73
Pr. ct. unburned Coal in Ash..	50.14	67	57.53	42.72	———	———
Total B. T. U. lost in Ash...	330100	1307400	1382400	496700	———	———
Lbs. of Coal per B.H.P. Hr.[1]	1.51	1.16	.999	1.3	———	———
Lbs. of Coal per K.W. Hr.	———	———	———	———	4.1	2.23
Fuel cost per *B.H.P. Hour	.45c	.35c	.29c	———	———	———
Fuel cost per *K. W. Hour	———	———	———	———	1.2c	.64c
Apparent load Factor...	———	———	———	———	.32	.54
Thermal Eff. of Plant......	15.69%	17.56%	19.69%	15.79%	9.44%	18.06%

*Coal $6.00 per ton.

The numbers I, II, III, and IV refer to one-fourth, one-half, full load and three-fourths brake load, respectively; number V refers to the test made with the generator carrying the lighting load only, and number VI with the generator carrying the lighting load and the electrically driven air-compressor. Since the load was more nearly constant in number VI than in V, the load factor was higher, hence better results were obtained.

During the three-fourths brake load test (No. IV), some trouble was experienced with the producer, hence we find the results for that run at variance with those of the other runs. The apparent load factor is the actual K. W. output for the run divided by the capacity output for the duration of the run. The cost per K. W. hour as given under runs V and VI includes the coal for banking and starting. The thermal efficiency was obtained by dividing the brake load equivalent in B. T. U. by the B. T. U. supplied in coal as fired.

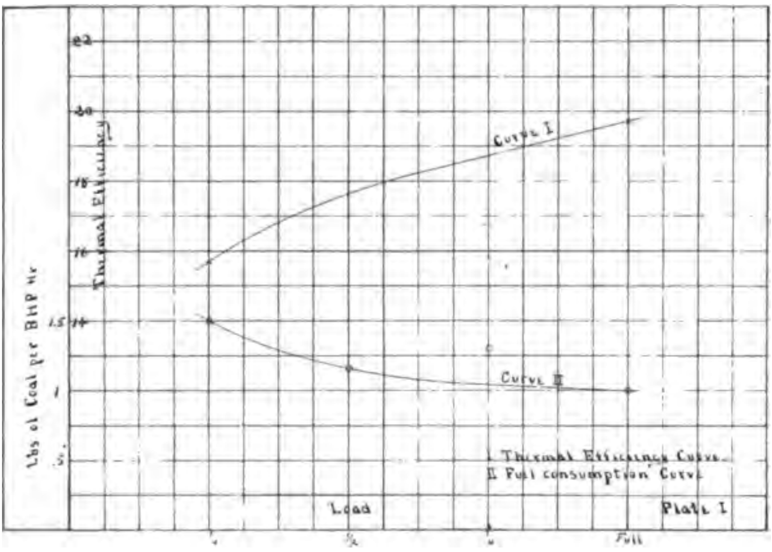
Table II contains a complete heat balance for the plant at

TABLE II.

HEAT BALANCE AT FULL LOAD.

	B. T. U.	%
In coal as fired	12143500	100
Converted into useful work	2391524	19.69
Lost in unburned coal in ash	1382000	11.46
Lost by radiation from producer	285000	2.33
Lost by radiation from scrubber	39000	.31
For heating water in vaporizer	79000	.65
Lost in scrubber water	887000	7.3
Lost in jacket water	2539000	20.9
Lost in exhaust	3856000	31.75
Unaccounted for	684976	5.61
Total	12143500	100

full load. Plate I shows graphically and in a clearer manner



the comparative results obtained in the brake tests. These results are interesting and tend to show the superiority of the gas producer plant, from a thermal efficiency standpoint, over that of steam.

Realizing the necessity of training the technical graduate in the operation of this prime mover which is to be a worthy competitor of steam, and desiring to do some original research work along this line, the department of Mechanical Engineering

purchased, and has just installed, a gas producer and engine. This producer is of the suction type, and is designed to operate on pea anthracite coal. The vaporizer surrounds the top part of the producer, and the water is heated as the hot gas rises from the fire pot. The engine is a two-cylinder, vertical, with a throttling governor, and is rated at forty-three brake horse-power. It is arranged with a combination brake and belt pulley, so that the engine can be used with brake load or belt load without changing the pulley. The plant was installed by the Fairbanks Morse Co. of Beloit, Wisconsin. Before the plant was accepted, it was run at full load for two days, after which an eight hour, full load brake test was made.

During this test, the plant generated a brake horse-power hour on 1.13 pounds of anthracite pea coal, and gave a total thermal efficiency of eighteen per cent.

During the next few months, the plant will be tested under various conditions, and with various fuels, and the results will be published from time to time as they are obtained. The department hopes, in this way, to bring the engineering public into closer touch with the facts regarding the gas producer plant for power purposes.

THE STATE'S RESPONSIBILITY IN ROAD IMPROVEMENT

BY DIRECTOR A. MARSTON, IOWA HIGHWAY COMMISSION.

There is going on at the present time an extended discussion regarding the relative functions of central and local authorities in the government of our country. This is the result of an unconscious movement in the United States toward the centralization of government functions, a movement which has resulted from the necessities of our complex modern conditions. It is found that disjointed, local efforts are no longer sufficient to meet the conditions of the present time. Laws which were entirely satisfactory when our factories consisted of a few hands working with the owner, in close personal relations with him, are no longer sufficient to meet the conditions imposed by the great trusts of today.

What is true of governmental functions in general is also true of the administration of our roads. In the old days the requirements were met sufficiently well by entrusting the entire control and improvement of the roads to local authorities. But at the present time it is believed that the state should assume part of the responsibility, and that an enormous waste and inefficiency result from leaving road administration entirely to disjointed local managements.

The fact is, our country roads have come to occupy a place in the life of our population enormously important as compared with the old conditions. Formerly each farmer was, to a large extent, his own manufacturer and consumer and he used little not produced or made on the farm. At the present time he takes full advantage of the world's factories, commerce, literature, and art, and finds it is economical to leave the manufacture of most of the articles which he uses to the world's factories. The result is that the road which connects him with the nearest satisfactory market has become a vital link in his everyday life.

It has been very commonly supposed that success in agriculture is the result simply of the use of the best methods of cultivation and management on the farm itself, whereas, in reality the successful agriculturist of today must take an active part in the transaction of business entirely outside of his immediate farming operations. He needs to know the prices prevailing in the world's markets each day, and to be able to buy and sell at any time of the year, independent of weather conditions.

His intellectual and social life, also, are exceedingly important as compared with former conditions. He must be able to receive his mail every day of the year, delivered at his home. He must be able to procure the best journals and books at will, and in every way must keep in close touch with the intelligence of the world.

In fact, we may say that the radius of the country world at the present day has been enormously enlarged, as compared with former times. Looking back to my boyhood days, I can see the picture of the portion of the world's surface closely known to me, as I presume each man can who was reared in the country. Extending out a few miles in each direction from the home place was a region intimately known to us, and it was mainly with the people living in this region that we had social and business relations of mutual advantage. We thought we were doing well to receive our mail once each week, and if any message was to be given to a neighbor it had to be transmitted by word of mouth. How different are the conditions at the present time! My father, who *then* seemed to me to be a man of advanced age, now receives his Chicago paper every day, and if he wishes to communicate with his neighbors he has but to take down the telephone receiver.

Nor should we confine our point of view to the country alone. The modern tendency is toward grouping our population in cities and towns. In Iowa the prosperity of the cities depends mainly upon the magnitude of the territory tributary to them, and upon the regularity and surety with which the in-

habitants of the tributary territory can maintain their business relations with the city. Any city which can secure the permanent improvement of the principal roads radiating out from it in all directions, will thereby do much to extend its tributary territory and to insure its business prosperity.

In the investigations of the Iowa Highway Commission of the statistics of the use of Iowa roads, that which has come out most prominently has been the exceeding importance of what might be called the light travel over these roads; that is, their use for other purposes than for the hauling of heavy loads. It is impossible to estimate the money value to the people of Iowa of having good, hard roads at all seasons of the year and under all conditions of weather, for the transaction of the business of the state, and for securing social and intellectual advantages which would otherwise be unattainable.

It is, however, a sad fact that country road improvement has not kept pace at all with the other advances of civilization in America. The present conditions are rapidly becoming intolerable. They constitute what might be termed, and will soon be regarded as, a disgrace to the state.

Yet, we are expending, at the present time, enormous sums upon our roads. The figures for the last three years are as follows:

Year	County Road Tax	Township Road Tax	County Bridge Tax	Total
1903	$547,309.92	$2,283,129.65	$1,628,720.88	$4,459,160.45
1904	559,409.42	1,749,395.23	1,947,423.53	4,259,228.18
1905	518,535.71	1,923,431.81	1,773,304.08	4,215,271.60

Taking into account the money value of the poll taxes, and the sums from other sources than those above enumerated that are expended upon the roads of Iowa, it is probable that the total annual expenditures for road purposes are between 4,500,000 and 5,000,000 dollars.

To form some idea of the magnitude of this great sum we may compare it with the total expenditures for state purposes in Iowa during the fiscal year ending June 30, 1906, which were $4,[illegible]. It appears, therefore, that the money expended on Iowa roads in one year is considerably in excess of the total sum required to run the state government and to support the state asylums, penitentiaries and all other charitable and penal institutions together with the State Normal School, the State University and the State College.

[illegible] a state legislature [illegible] its ordinary expenses [illegible] Iowa has not taken as a state any part in [illegible] the expenditures of

the road funds. Apparently, however, the inevitable force of progress is compelling the state to participate more actively in securing efficient results from its large expenditures on roads.

It is a matter of common knowledge that we do not, under the present system, secure the results to which we are entitled for the amount of money expended, although our road officers are almost universally absolutely honest, and have the best of intentions. The fault is in the system, in the lack of the *training* of the men, and not in the men themselves. It will be of interest to inquire what results we could reasonably expect from the money now being spent upon our state roads with proper system, and with thoroughly trained men.

In the first place, we may say that Iowa has approximately 100,000 miles of country roads and that at a maximum expense of five dollars per mile, or a total of $500,000 annually, these roads could be maintained in good condition during almost all the year by the proper systematic use of the road drag. If, therefore, our road work were systematized under well trained, responsible men, $500,000 could be expended each year, with results which would be many times more valuable than at present attained with the expenditures of our entire road funds.

In the second place, nearly all the moneys expended for bridges should be put into permanent structures, such as concrete culverts, and steel bridges with masonry abutments. If this policy were followed for a considerable period of years the annual amount required for bridges would greatly diminish. In this way $1,500,000 to $2,000,000 could be profiitably spent annually for a number of years to come.

In the third place, $1,000,000 per year could be concentrated upon the improvement of the main travelled roads of the state, including the surfacing of such roads with gravel, broken stone, or other material suitable for making permanent improvement. At prices which have actually realized in the state, this would be sufficient to build 1,000 to 1,500 miles of gravel road per year, two hundred to four hundred miles of stone road.

In the fourth place, there would be left $1,000,000 to $1,500,000 for general administration and for grading. The grading done with this fund should be devoted to building good, substantial grades and side ditches, in accordance with road engineer's plans, instead of patching a little here and a little there. Several million cubic yards of earth per year could be moved with this fund.

It is not too much to say that if the administration of the road funds of Iowa were under the management of one of our great railway systems, all the above results would be secured,

and that within a comparatively limited number of years we would have a system of roads that would be the admiration of the world, without taxing ourselves any more than we now do. It is impossible, of course, to actually secure such perfect business administration, while still leaving the control of our road funds as closely to the people who pay the taxes as is right and desirable under our system of government. But we should approach much nearer to this ideal than at present. Under the present conditions we see little improvement from year to year, and the money seems to go to just about keep up the roads in their present condition.

To *systematize and concentrate* our road work must be our endeavor if we would improve present conditions.

Until recently, our state has taken no part in road administration further than to pass uniform road laws. This is a function of state government which has, of course, been recognized in every state in the union. But while the laws are uniform in each particular state, in their administration we find wide differences in practice in different parts of Iowa. There is, perhaps, in fact, a more pressing need for an exact and uniform enforcement of our present road laws than for the enactment of new laws. For example, the laws require a proper accounting of road funds, yet we find that the actual system of accounting is often hardly worthy of the name.

Of recent years there has been a general movement in the United States towards more active participation by the state in road administration, and this has shown itself in the creation of state highway commissions. California, Connecticut, Idaho, Illinois, Iowa, Minnesota, Massachusetts, Michigan, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Vermont, and Washington have created such commissions. Taking the cases of some of our neighboring states, it may be stated that Illinois appropriates $50,000 per year for its highway commission; that Missouri has just provided for a state highway engineer, with an appropriation of $12,000 per year for expenses and has further provided for a county road engineer in each county of the state. Iowa has provided that the Iowa State College shall constitute a highway commission, and has appropriated $5,000 per year, which amount is the lowest provided by any state for its highway commission.

The duties of these highway commissions vary from mainly investigation and advisory work, to active building and maintenance of state roads. The work of our own commission may be said to have just begun. So far, we have been making a thorough preliminary study of road conditions in Iowa, have prepared and distributed road bulletins, have prepared and have

been furnishing to road officers standard plans for culverts, bridges, and road construction, have inaugurated an annual road school for the training of road officers, have furnished expert advice to road officers calling for it, both by correspondence and personal visit, and have been endeavoring to assist further in the road work in all ways possible.

Another very important method by which the states of our country have been taking active part in road work in recent years is state aid. Connecticut has available about $225,000 per year for the construction of state roads, the state paying ninety-five per cent of the cost. Massachusetts appropriated in 1905 about $550,000, paying seventy-five per cent of the total cost. In New Hampshire the amount is $125,000 per year, the state paying from twenty-five to seventy-five per cent of the cost. New Jersey which shares with Massachusette the honor of pioneering the way in state road construction, expends annually $400,000 paying one-third of the cost. New York has recently appropriated $50,000,000 for state roads, to be expended in ten years, and pays fifty per cent of the cost. Pennsylvania appropriated $6,356,232, to be expended in five years ending 1909, and pays seventy-five per cent of the cost. Washington pays fifty per cent of the cost of all roads built by the state highway commissioner. Michigan pays "state rewards" for gravel and macadam roads, ranging from two hundred fifty to one thousand dollars per mile, according to the kind of road built, when same have been constructed according to the plans and specifications of the state highway commissioner and have received his approval.

While there might be much doubt in the minds of many people whether as yet Iowa has reached the time for extending state aid for hard roads, yet all who have studied those built under this system in our eastern states must admit that they are the finest roads in the world. And the plan is so popular with the tax payers who foot the bills that in every state having such a system there are continual demands for the construction of many more such roads than can possibly be built. At the same time those making the requests understand that they have personally to pay a large part of the cost in addition to the amount paid by the state. The macadamized roads built by New Jersey, Massachusetts and New York under the system of state aid road construction are ideal, and are unsurpassed in the world, whereas, a few years ago these same states had roads equal to the worst.

In conclusion we may inquire what can be done in Iowa by the state to secure better roads. I will enumerate certain things which we believe our state could well undertake.

In the first place the state should systematize our road work.

(1) Its highway commission will supply to all road officers desiring them standard plans for culverts, bridges and road construction. We believe the state should require that all plans and specifications for large bridges be submitted to and approved by the commission, and that the construction of culverts and roads should, in general, be carried out in accordance with standard plans.

(2) The highway commission should supply road experts to respond to the call of road officers for advice and assistance.

(3) The state should by law provide for a road engineer in each county of the state, who should be a trained and well qualified road expert, who should make surveys and prepare plans for all important road work, and under whom in general the road work of the county should be placed. These county road engineers should be required to make regular reports to the highway commission, and to keep in close touch with it.

(4) The local road officers of each township should be required to make regular reports to the county engineer, and in general to work in consultation with him.

(5) Means should be provided for educating and training road officers. The present Road School should have its facilities for such work greatly extended and, if necessary, should hold a number of sessions each year in different parts of the state, so as to make it more convenient for road officers to attend.

In the second place our present road funds should be expended in such a way as to secure better results for the money.

(6) Systematic dragging of all earth roads, except unused byways, should be required, and should be carried out under road officers who can be held responsible for results.

(7) The expenditures for culverts should be devoted mainly to the building of permanent concrete structures.

(8) All large steel bridges should be built in accordance with definite plans and specifications prepared by competent engineers and let to the lowest responsible bidder, after being properly advertised.

(9) The county road fund should be increased one mill, and in general the road work should be to a considerable extent concentrated on main travelled highways.

(10) Wherever practicable, a beginning should be made at surfacing the principal roads with the best gravel or stone or other hard material locally available.

In the third place, the state should by direct appropria-

tion provide for the building by the State Highway Commission of sections of experimental road in different parts of the state. In no other way can the best materials available in Iowa be discovered and the cost of good roads construction be ascertained.

The road question in Iowa is one of the most important to be solved by our people. The traffic on these roads is so large that if teams could be collected in one string to do the annual travelling in one day, at thirty miles per day, this string of teams would reach more than one and one-half times around the entire earth. In every way is the attainment of good roads most vital to our people. We must believe that the problem will be successfully solved in our state, and that Iowa roads, as well as Iowa agriculture, will in the future be found in the first rank.

PHYSICAL TESTS OF IOWA LIMES

BY IRA A. WILLIAMS.

GENERAL CONSIDERATIONS.

The lime of commerce is produced by the calcination of limestone and varies in composition and purity as do the limestones themselves. The latter range from practically pure calcium carbonate ($CaCO_3$) to the sandy and clayey limestones in which the impurities compose a large percentage of the rock. Again, the calcium may be in part replaced by magnesium which gives the magnesian limestones. If this replacement has taken place to the extent that magnesia (MgO) comprises eighteen to twenty per cent of the stone, the term dolomitic limestone is more commonly applied.

A limestone composed essentially of $CaCo_3$ will furnish a high grade of quicklime, one containing little else than CaO; one composed of $CaCO_3$ with a greater or less percentage of $MgCO_3$ will afford a magnesian or dolomitic lime: while the argillaceous limestones will give a product of a degree of purity depending on the amount of clay in the original stone. The properties of the resulting limes will vary according to their composition.

Limestones are widely distributed in nature, both geographically and geologically. They are found interbedded with and overlapping other common sedimentary strata, and they have been produced in much the same way as other sediments. Good reasons are readily conceived why they should be apt to partake of the nature of, and to grade into or be contaminated with, other sedimentary materials. It is, nevertheless, not at all uncommon to find limestones that run over ninety per cent lime carbonate, and occasionally as high as ninety-eight or

ninety-nine per cent. The analyses of nine samples of non-dolomitic Iowa limestones show a range of from 82.5 to 97.02 per cent carbonate of lime, three of the nine samples showing over ninety per cent.

As indicated, limestones depart in composition most commonly in the content of magnesia and in the clay and sand impurities. The effect of these substances on the resulting lime is of so much importance that they may be given separate consideration.

WHITE VERSUS BROWN LIMES.

A pure limestone when burned changes to calcium oxide (CaO) by the loss of carbon dioxide (CO_2) gas. The resulting lime is the white lime of commerce. It slakes readily and rapidly, with the evolution of much heat and becomes a perfectly white paste. The chemical reaction in slaking is:

$$\underset{\text{CaO}}{\text{Quicklime}} + \underset{\text{H}_2\text{O}}{\text{Water}} = \underset{\text{Ca (OH)}_2}{\text{Slaked lime}} + \text{heat}$$

This reaction with CaO furnishes with maximum intensity all the evidences of the chemical change which is taking place. Any impurities in the quicklime, which may have been present in the limestone, tend to retard and to make less vigorous the slaking process, but the quantity of the impurity must be considerable before any pronounced interference will be noticeable.

Dolomitic limestones are very common and produce limes that slake slowly, evolve less heat and are of a gray or brown color. Over ten per cent of MgO must be present to appreciably alter the properties of a lime. Limes containing less than ten per cent MgO are accordingly spoken of as magnesian limes, while those with over ten per cent are properly called dolomitic or brown limes. Dolomitic limes produced from Iowa limestones range in magnesia content from 15.23 to 35.73 per cent MgO in the marketed product.

With reference to the amount of magnesia contained, therefore, limes may be classified; (a) hot, white or high-calcium limes when MgO is below ten per cent; and (b) cool, brown, or dolomitic limes when MgO is over ten per cent. The value, properties and adaptability of the two classes will be briefly treated later.

WHITE VERSUS ARGILLACEOUS AND SILICEOUS LIMES.

Limestones which contain clayey matter produce limes that are gray in color and less vigorous in their action than the pure white limes. Sand or other siliceous impurities in the lime do not ordinarily exert any influence on its physical properties, acting simply as a diluent in the same way that sand does in a

mortar. Should the latter be excessively fine, however, it may become susceptible to chemical combination with the lime if high temperatures are employed in the burning. As the amount of sand and clay increases, limestones are called sandy or arenaceous and argillaceous, and when these materials become the predominant constituents, the rock passes into calcareous or limy sandstones and shales.

The presence of a small proportion of the above named impurities causes limes to become hydraulic, that is, to possess the property of hardening under water, by the gradual taking of water into chemical combination. When the quantity of clayey impurities in the limestone reaches six per cent, they begin to produce hydraulicity. Below six per cent the only noticeable effect is in the retardation of slaking. Limestones carrying six to twelve per cent furnish limes that are cool and slow slaking, gray in color and make the best of mortar if burned at ordinary lime kiln temperatures. There is, however, much greater danger of overburning than in the case of white limes as the clay has a tendency to combine with the lime, which decreases its value unless finely ground. Fifteen to twenty-five per cent of clay renders a lime strongly hydraulic if properly burned, but care is required to avoid overburning and consequent clinkering. If clinkering is permitted to take place, the product is found to possess, after fine grinding, a hydraulicity greater than that of the hydraulic limes and similar to cement, which property becomes more prominent the greater the clay content and the higher the temperature of burning. The limit at present is Portland cement in which the raw materials are artificially blended and thoroughly clinkered at very high temperatures.

It is clear, therefore, that limes are but one end of a series of products of which Portland cement is the other. The dividing lines separating the various members of the series that are put upon the market are to some extent arbitrary. The following four divisions are commonly referred to:

1. Common or fat limes.
2. Hydraulic limes.
3. Hydraulic or Roman cements.
4. Portland cement.

The points of distinction between 1 and 2 have been noted. In composition, 2 and 3 are not separable. By an increased temperature in burning some hydraulic limes will become hydraulic cements. Twenty-four per cent of clay is about the permissible upper limit for the hydraulic limes, while Roman cements are in use which contain but little over twenty per cent of clayey impurities. The chief distinguishing feature of these

two groups lies in the ability of the limes to slake to a paste with water without previous pulverization. Fine grinding is necessary before water will affect appreciably Roman cements and before they will harden as a mortar.

The feeble hydraulicity of the limes and the relatively strong of the cements appears to be due to the varying degree to which chemical combination has been brought about in burning. In lime burning, little if any chemical action occurs between the lime and the clay. What does take place tends to produce an unstable or 'unlocked' condition of the clay and other siliceous materials such that, in the presence of water, the lime hydrate slowly attacks these and combines with them to form silicates that are harder and more durable than ordinary lime mortar. Clinkering in burning, is an indication of chemical action, further progress in rendering available and susceptible to the attack of the lime and water the clay and other siliceous substances in the stone. Burned to this condition, the product is properly termed a cement and in use attains a stony hardness and relatively great permanency.

Hydraulic or Roman cements are spoken of also as natural or rock cements, since they are made from limestones in which the ingredients occur naturally in the proper proportions. Such limestones are found in different parts of the United States, but have been utilized principally in the Appalachian states of the East and along the Ohio river. The actual composition ranges between wide limits as shown in the table below in which are compiled the analyses of five reputable brands of natural cements.

NAME	Silica	Alumina	Iron oxide	Lime	Magnesia	Alkalis	Loss on ignition
"Fern leaf" brand, Louisville, Ky.	26.4	6.28	1.00	45.22	9.00	4.24	7.86
N. L. & C. Co., Rosendale, N. Y.	30.5	6.84	2.42	34.38	18.00	3.98	3.78
"Hoffman," Rosendale, N. Y.	27.3	7.14	1.80	35.98	18.00	6.80	2.98
Utica Brand, Utica, Ill.	27.6	10.60	0.80	33.04	7.26	7.42	2.00
Mankato, Minn.	28.43	6.71	1.94	36.31	23.89	1.80	0.92

Numbers 3 and 4 in the outline on page 217, bear to some extent a similar relation to that briefly given for 2 and 3. A more complete vitrification of the ingredients in the cement mixture

until they issue from the kiln as thoroughly vitrified clinker produces the maximum amount of hydraulic silicate. The chemical changes which occur in burning are complicated and become more so the higher the temperature over that employed in the manufacture of natural cement. Just what these changes are is not accurately known, but experimentation has determined within fairly narrow limits what proportions of the various constituents entering into a mixture of clay, silica and limestone will produce the greatest amount of unstable, hydraulic silicate, and what temperatures are required to accomplish this result. These proportions and temperatures are employed in the manufacture of Portland cement and are not considered in this article.

The foregoing remarks will serve to show the relation of limes as a mortar material to other substances used for similar purposes. This paper has to do with limes alone and the several physical properties of the latter that are of chief importance will be briefly discussed.

SLAKING.

The property belonging to limes which makes them of industrial value is their ability to slake or crumble to a powder on the addition of water, and to harden when allowed to stand in contact with the atmosphere. The reaction which occurs in slaking has already been given. If a lime is properly burned, all lime carbonate in the original stone has lost its carbon dioxide, and becomes quicklime (CaO). It is the rapid change accompanied by the evolution of heat when water is added that causes lime to slake.

Slaking is a physical evidence of the hydration of lime, but it is not to be understood that slaking is a necessary result of such chemical action. The two processes are really distinct. The exposure of caustic lime to a moist atmosphere occasions slow hydration, accompanied by crumbling to a powder. Along with this change occurs an increase in volume of about one and three-fourth times that of the original lime. Such lime is air-slaked and is largely changed to the hydroxide, $Ca(OH)_2$. If this lime be exposed to water, it will further increase in volume, but the paste resulting will be sharp and sandy in texture, and of much less value for mortar purposes than freshly slaked lime. In this case a portion of the CaO has no doubt combined with the CO_2 of the air, so that air-slaked lime is actually a mixture of lime hydrate and carbonate. It is possible also to bring about the complete hydration of lime by steam at temperatures above boiling, without any change of volume or any sign of crumbling.

Slaking may therefore, be defined as the hydration of cal-

cium oxide, quick-lime, accompanied by an increase in temperature and volume. The increase in temperature is caused by the combination of the lime and water. It is an exothermic reaction, one in which heat is evolved. Whether or not this heat becomes evident depends on the vigor and rapidity of the reaction.

Slaking is commonly accomplished by the addition of sufficient water to cover the lime, and by further additions as needed. It is desirable from the practical standpoint that the greatest possible increase in volume be secured in slaking. This is accomplished by careful control of the amount of water throughout the process. The evolution of heat in such quantities as to generate steam within the mass is a necessity to the slaking process. At the same time, more water than simply that required for hydration is essential. It is the expansion of the steam between the molecules of hydrating lime which forces them apart and causes the mass to crumble. As the particles are separated, the surrounding excess of water acts to remove them, as in the case if any fine sediment, and, as they settle away in partial suspension, new surfaces of the lime are constantly exposed. A large excess of water prevents proper slaking by keeping the temperature so low that the necessary steam does not form. The mass then expands poorly, slakes slowly, and the product is lumpy. The lime is said to be 'drowned.'

The result of too little water is a 'burnt' lime. In this case, the water forms a gelatinous film of hydroxide over the surface of the lumps which dries down, enclosing caustic quicklime in the center, and so clogs the pores that further progress is much retarded or prevented. When too little water is used, the initial action is apt also to be so violent in the case of 'fat' limes, that much or all of the moisture passes off as a vapor, because of the excessive temperature developed. This frequently leaves the lime but partially hydrated, dry, and imperfectly slaked.

Dolomitic limes slake more slowly and at a much lower temperature than high-calcium limes. The heat generated is due to the hydration of the calcium oxide, the magnesia remaining as the oxide during slaking. Although magnesium carbonate loses CO_2 at a lower temperature in burning than does the carbonate of lime, it hydrates only with difficulty and probably passes directly from oxide to carbonate in the hardening process. It is thus necessary to add the water required very gradually in slaking dolomitic limes in order to avoid 'drowning' and to secure the best results.

The proper amount of water to use varies, and can be as-

certained for each individual lime only by actual trial. It is usually found more satisfactory to add the water in several different portions as slaking progresses, especially with the lean, slow slaking and dolomitic limes. In this way, by a little attention, the temperature of the slake can be controlled so that the best product is obtained from the lime in use.

The expansion of volume in slaking may be as high as three and one-half times with pure white limes. It is found to range from two and one-half to the figure named. Lean, so called hydraulic limes, and dolomitic limes expand less. Increase in volume is ordinarily estimated by a comparison of the bulk of the dry quick-lime and of the paste after slaking. Careful experiments with samples of both high-calcium and dolomitic limes made by the Ohio Geological Survey* show an increase in apparent volume for the white limes of from one hundred thirty-six per cent, using twenty per cent less water than theoretically necessary for hydration, up to two hundred sixty-four per cent with forty per cent excess of water. With three hundred per cent excess, the increase was but forty-five per cent. The comparison was made between the apparent volumes of the ground quick-lime and of the dry hydrate produced. Under the same conditions, a dolomitic lime gave one hundred ninety-three per cent expansion with a deficiency of twenty per cent of water, of two hundred ten per cent with the exact theoretical quantity of water, and of but about twenty per cent with an excess of water. The increase in volume is decidedly in favor of the white lime, the smaller expansion of the dolomitic lime being accounted for, no doubt, by the fact that the magnesia takes up very little water in the slaking process.

The *actual* increase is, as a matter of fact, more apparent than real. The calcium hydroxide produced from a weighed amount and accurately determined volume of calcium oxide will occupy a space but thirty-five to forty per cent greater than the volume of the oxide. Few experiments have been made along this line and the above figures were obtained with a high grade white lime by the use of the Seger volumeter.

If allowed to stand in the air lime deteriorates by the process of air-slaking already described. It also slowly absorbs carbon dioxide, which renders it of little value for mortar. After slaking, if the paste is not to be used at once, it should be protected from the atmosphere, since moist lime hydrate changes very readily to the carbonate by the absorption of CO_2. Slaked lime is very commonly buried so as to be covered with several inches of soil, where it will keep for months without deterioration.

*S. V. Peppel, Bulletin 4, Ohio Geol. Survey (4th series), p. 337.

Owing to the susceptibility to deterioration of high-calcium limes on the one hand, and the exceeding slowness with which dolomitic limes slake on the other, so-called 'hydrated limes' are being put upon the market.

The quick-lime is subjected to a partial hydration or slaking at once after burning and before being sacked or barrelled. The completeness of the hydration in the case of five Ohio* products ranged from fifty-eight to ninety-four per cent, one hundred being taken as the best that is possible on a commercial scale. Specially designed and patented apparatus and processes are being employed in the hydration of limes, but it is believed that such special equipment is not necessary, nor will the preparation of hydrated lime without doing so under a patent, make any person liable for infringement. So far as known hydrated lime is placed on the market from but one Iowa kiln.

The desirable qualities of hydrated lime are (1) its convenience in use, for it is already pulverized and but little time is required to make a mortar by mixing the ingredients dry before adding the water; (2) its lasting qualities, as it will keep much longer without detriment than the unslaked product. Magnesian limes are more commonly prepared in this way, and the saving of time in their use is a very important commercial consideration. Hydrated magnesian limes are found by the Ohio Survey† to have specific gravities of 2.12 to 2.25. High-calcium limes run about 2.45. A series of tests with an Iowa white lime gives specific gravities from 2.2 to 2.32 for the slaked lime, while the quick lime is 2.08.

SETTING AND HARDENING.

In slaking, the lime takes water into chemical combination, and becomes the gelatinous hydroxide. When this hydroxide is put in place as a mortar, it is said to set. This preliminary set is due to the loss of the water used in mixing, which brings about a certain rigidity in the same way, so far as is known, that clay becomes hard on drying. Part of the moisture evaporates from exposed surfaces, but the larger proportion is in most instances absorbed by the porous brick or other masonry material with which it is used. The more rapid the set, that is, the more rapidly the mortar loses its water, the safer the construction, providing the proportions of sand and lime are such that shrinkage may be left out of account.

A second process begins at once when the lime is exposed to the air. This is the absorption by chemical combination of carbon dioxide by which the lime returns to the carbonate condition, as it existed in the original limestone. The process is a slow

*S. V. Peppel. Bulletin 4, Ohio Geol. Survey, pp. 335 and 336.
†S. V. Peppel, loc. cit.

one and may require years for completion, but this depends largely on the surface that is exposed, the thickness of the layer and porosity of the mortar. A large number of chemical tests on small briquettes having a minimum cross section of one square inch, made with mixtures of sand as high as 6 to 1, and allowed to stand for a maximum period of one year, showed none in which carbonation was complete. This action is most rapid in the first few months until a crust of the carbonate forms on the exterior, The crust retards the process and at the same time protects the soluble hydrate within from being dissolved. The interior portions of large masses may therefore, never reach this final condition in hardening.

Long contact of lime hydrate with finely divided silica is known to cause a reaction by which the silica combines with the lime forming a stable silicate of lime. The extent to which this reaction progresses depends on the physical and chemical qualities of the siliceous impurities in the lime or of the sand used with it. If these are very fine, chemical action is favored. Silicates, such as clay or feldspar, for example, are more susceptible to attack by the lime than is quartz sand. Hydraulic limes are apt, therefore, other things being equal, to give a more durable final product than the purer limes. In the same way, muddy or clayey sand used with lime, although less desirable at the start, will likely contribute to the durability of the mixture in time because of the development of these stable compounds by the caustic action of the lime. In the case of silicates, it is probable that other elements, especially alumina, also enter into combination.

LIME MORTAR.

Sand. Lime has a variety of uses in various industries but by far its most important application is and has been as a mortar in structural work, interior wall plastering, etc. For these purposes, slaked lime alone cannot be used on account of the great shrinkage of the lime paste in setting and its lack of inherent strength when set. It is, at the same time, economical to add some foreign material which is cheaper than the lime itself. The filling material commonly employed is sand. Most sands are composed largely of quartz grains, although fragments of feldspar and of many other minerals are often found in varying amounts with quartz. There is often also more or less of earthy or clayey matter in sands.

In general, it may be said that the composition of the sand is not an important consideration. Any inert substance which does not shrink nor deteriorate may be used. Ground limestone, for example, or the pulverized sand from any durable rock will serve the purpose equally well.

The physical condition of the sand is however, of considerable importance. The function of the lime is to serve as a binder to hold the particles of the aggregate together. If these particles are angular and rough, they afford good surfaces for the attachment of the lime. Sharp sand will therefore make a stronger mortar than one composed of rounded grains. Only sufficient lime is required to fill the voids and to form a thin film around each grain of the aggregate. The more nearly the voids are filled with the sand grains themselves, in other words, the smaller the percentage of pore space in the sand, the less the amount of lime needed. A sand composed of a properly proportioned range of sizes of grain will therefore not only give the strongest product but will do so with the least amount of lime. Few sands as they occur naturally are composed of the proper range of size to give the smallest pore space. It is sometimes not difficult, and often may be a matter of economy, to correct a poorly proportioned sand by screening or by the addition of suitably graded materials. The voids in a sand are determined readily with simple apparatus.* Separation into a series of sizes is quickly done by sieves of a number of different meshes. These two tests afford data as to how far a given sand departs from the ideal mixture of grains and indicate the size of grain and quantity to be added for correction.

The sand grains should be practically in contact throughout the mass so that the lime paste forms merely a plastic film filling the interstices. Such a mortar when it has attained its final hardness may properly be regarded as sandstone in which the cementing matter is lime carbonate. It differs from the natural stone only in its position and origin, being as strong, if properly made, and as durable as that quarried from natural ledges.

White limes shrink much more in drying than do dolomitic limes. For this reason it is more highly important that the proper proportion of sand be used with the former. The binding or adhesive power of white lime is also less. This is evidenced in walls where the mortar separates readily from the brick and can itself often be crumbled in the fingers. Such defects are believed to be due more to poor mixing and wrong proportions of sand and lime than to any inherent quality of the lime itself. On the other hand, dolomitic limes possess great adhesive strength and not only form a denser mortar by binding the sand particles firmly together, but contribute towards the stability of the wall by adhering to the brick or stone.

*Standard Sand for Cement Work, M. J. Reinhart, Proc. 3d Ann. Convention Iowa Association Cement Users, Iowa Engineer. Vol. VII, No. 1, p. 34.

TESTS OF LIME MORTARS.

Although lime has been used as a mortar since very early times, and is of late being employed in various other ways in structural engineering work, few records of tests of those physical properties which make it of value are to be found. The purpose of the following series of tests is to investigate several of the physical properties of lime mortars, covering the following points:

(a) The influence of slaking with increasing amounts of water;

(b) The increase in strength with increased setting periods, and, since in practice, limes are seldom used in a neat condition;

(c) The effect of varying proportions of sand on the strength of the mortar, and the rapidity of setting.

There has also of late been considerable discussion as to the relative merits of the white or high-calcium limes, and the brown or magnesian limes.

To obtain definite data on these several points, the following plan was adopted in the beginning. Barrel samples of commercial limes were obtained from the principal producers in Iowa, and a few from bordering states. Samples of white lime were tested from Springfield, Mo., and Mason City, Iowa; of dolomitic lime from Viola, Iowa, Mason City, Iowa, Maquoketa, Iowa, and Eagle Point, Iowa.

While it was evident that the factors enumerated above were the important ones to be studied with each lime, it was necessary to carry on considerable preliminary experimenting in order to be able to lay out an exact systematic method of procedure. A provisional line of experiments was therefore initiated, using the white lime from Mason City. The quick-lime was slaked with percentages of water ranging from the amount which would produce a dry powder as a minimum, to a maximum of 300 per cent by weight. Slakings were then made with 100, 150, 200, 250, and 300 per cent of water, calculated on the basis of dry quick-lime as 100 per cent. From each slaking, series of briquettes were made with the following sand dilutions,* by weight:

One part sand to 1 of lime, 1½ of sand to 1 of lime, 2 of sand to 1 of lime, and so on to 5 parts of sand to 1 of lime. Four sets of briquettes were made from each sand mixture to be broken at the end of four, eight, twelve, and sixteen weeks respectively. Ten briquettes were used in each set from which to obtain an average.

Briefly, then, from the lime paste obtained by slaking in each of *six* different percentages of water, briquettes were made with *nine* different dilutions of sand. Since four periods of

*A standard river sand was used throughout the tests, whose grains passed a 20-mesh (linear) sieve and remained on a 30-mesh sieve.

set were to be allowed, with ten briquettes to be broken at the expiration of each period, a little arithmetical calculation will show that for each lime tested, according to this plan, 2160 briquettes would be made. As the work progressed, it was soon discovered however, that this general scheme required more or less modification according to the peculiarities of each particular lime.

HIGH-CALCIUM WHITE LIMES.

LIME FROM MASON CITY, IOWA.

The limestone from which the Mason City lime is produced comes from the Devonian beds, and has the following analysis:

Water	0.51
Insoluble	.63
Alumina and iron oxide	.71
Lime (CaO)	54.59
Carbon dioxide	42.89
Magnesia (MgO)	.47
Carbon dioxide	.52
	100.32

Analysis of the commercial product:

	Quick-lime	After slaking
Insoluble	1.02	0.60
Alumina and iron oxide	2.98	2.80
Lime (CaO)	95.40	71.10
Magnesia (MgO)	.43	.40
Loss on ignition	0.00	25.60
	99.83	100.50

A sufficient quantity of quick-lime was slaked at one time to make the full number (360) of briquettes as planned for each percentage of water. Precaution was taken in slaking to add the water in such quantities and to agitate the mass so as to facilitate the process and to obtain the greatest increase in volume with the amount of water employed. The lime paste was allowed to stand for twenty-four hours until all signs of heat had disappeared and then put into air-tight jars to be used as needed. All weights were calculated on a dry basis, the moisture being determined before each batch of both sand and lime was weighed out. In the case of the higher percentages of water, it was necessary to drive off by careful heating, care being taken to keep the temperature below boiling, some of the excess water, in order to reduce the paste to a workable consistency. One man did the work, using his judgment to obtain as nearly as possible the same consistency in every batch. Forty briquettes were made

from each mixing. The briquettes remained in the molds until they could be safely removed, after which they were placed on edge on open shelves and allowed to harden for their respective periods.

The tensile strength test was adopted as a means of obtaining comparable results more because of its convenience and the uniform treatment to which each lime would be subjected, than as representing conditions which lime mortars would meet in actual use. As noted earlier, the principal function of a mortar is to serve as a matrix or adhesive to bind together particles of aggregates and sections of masonry structure. Adhesion, therefore, and crushing strength tests would give more direct results. Such tests have not as yet been made.

Records of tensile strength tests of lime mortars are to be found in the Report of the Secretary of War for 1896, Document No. 2, Volume II., part 5, on page 2839. These tests were made with paste slaked with 300 per cent of water, ratios of sand from 3:1 to 17.7:1, and setting periods of twenty-eight and twenty-nine days and three months. Average strengths range in the short time tests from sixty-four pounds with a ratio of 8.8:1 to twenty pounds per square inch with a sand-lime ratio of 17.7:1 and, in the three months tests from seventy-one pounds with a ratio 8.8:1 to thirty-six pounds with a ratio of 17.7:1. Tensile strength has also been investigated by the Ohio Geological Survey.* The following table will indicate the results obtained.

PHYSICAL TESTS OF OHIO LIMES.

Kind of Lime	Tensile strength of mortar after 7 days. Mortar made by adding 4 volumes of sand to 1 volume of quick-lime.	Remarks
High-calcium or white lime.	48.95	Water 20% less than theory for complete hydration.
	70.6	Theoretical amount of water.
	59.	100 % excess. Product, moist powder.
	42.36	Broke badly. Defective briquette. 100% excess. Heat applied in slaking.
	48.95	200% excess. Moist, lumpy mass.
	65.90	Briquette cracked before going into machine. 300% excess. Smooth stiff putty.

*S. V. Peppel, Bulletin IV, p. 337.

Dolomitic or brown lime	24.48	Bad briquette. 20 % less water than theory for complete hydration.
	77.2	Theoretical amount of water.
	58.	Bad briquette. 20% excess.
	81.90	40% excess.
	82.84	Sticky, lumpy mass. 100% excess.
	68.	Bad briquette. Stiff putty. 200% excess.

The period of set allowed in these tests is entirely too short for valuable results. But one briquette seems to have been made for each percentage of water. It is evident that a much larger number should be used to obtain an average figure.

A similar line of experiments made by Mr. George S. Mills, of Toledo Ohio,* affords results which bring out quite clearly the relative strength of the white and brown limes and the relation of strength to progress in setting and hardening of the mortar. The mortar was made with two parts sand to one of slaked lime by weight. The strength is expressed in pounds per square inch. From four to six breaking strengths were used for each time period to obtain the average results given in the table.

	1 mo.	2 mo.	3 mo.	4 mo.	6 mo.	1 year
Dolomite lime......		28.8	37.2	51.	83.	92.8
High-calcium lime.	30.7	36.6	39.2	39.	50.8	44.6

The Mason City lime is a hot lime, which slakes vigorously and requires constant attention when water is given to it. The quantity of water which would just leave the hydrate practically a dry white powder when it had cooled to the atmospheric temperature was found to be about seventy-five per cent of the weight of the dry hydrate.

The table below and the accompanying curves give in detail the breaking strength of the briquettes made with the Mason City lime. A Fairbanks standard testing machine was used.

*Municipal Engineering, Vol. 28, p. 6.

TABLE I.

SLAKED IN 75 PER CENT. OF WATER.

Time of Set in Weeks	Ratio Sand to Lime	Lbs. per sq. in. Average	Lbs. per sq. in. Maximum	Lbs. per sq. in. Minimum	Ratio Sand to Lime	Lbs. per sq. in. Average	Lbs. per sq. in. Maximum	Lbs. per sq. in. Minimum	Ratio Sand to Lime	Lbs. per sq. in. Average	Lbs. per sq. in. Maximum	Lbs. per sq. in. Minimum
4	1:1	48.4	51.4	38.5	1½:1	45.7	50.5	39.5	2:1	54.5	64.4	46.1
8		50.6	56.3	47.5		40.7	44.5	35.0		54.3	63.3	48.0
12		56.1	60.4	45.0		47.1	50.0	44.3		48.5	52.5	46.0
16		53.9	50.0	42.0		46.2	49.4	40.8		52.0	55.9	41.2
4	2½:1	55.1	60.4	50.4	3:1	50.6	56.2	41.9	3½:1	48.7	55.0	30.0
8		54.6	58.6	51.0		52.6	58.4	44.5		52.1	26.0	46.5
12		46.7	48.5	43.5		48.1	51.0	45.9		48.0	54.3	42.7
16		52.3	56.9	49.5		43.4	48.6	33.6		32.9	53.0	21.5
1	4:1	47.2	51.4	43.5	4½:1	43.7	53.0	35.0	5:1	43.6	58.4	38.0
8		47.8	57.0	37.0		41.8	52.5	37.0		45.9	50.0	34.4
12		43.6	49.5	33.7		42.6	46.6	38.4		42.5	51.4	28.6
16		41.5	49.0	28.8		44.6	50.0	33.0		53.1	55.7	50.0
4	5½:1	37.1	44.1	28.8	6:1	36.0	39.6	34.6				
8		37.8	45.0	32.6		35.9	39.0	31.0				
12		38.5	44.1	33.3		33.1	39.4	29.8				
16		38.6	40.8	34.9		35.4	41.6	30.0				

SLAKED IN 100 PER CENT. OF WATER

Time of Set in Weeks	Ratio Sand to Lime	Lbs. per sq. in. Average	Lbs. per sq. in. Maximum	Lbs. per sq. in. Minimum	Ratio Sand to Lime	Lbs. per sq. in. Average	Lbs. per sq. in. Maximum	Lbs. per sq. in. Minimum	Ratio Sand to Lime	Lbs. per sq. in. Average	Lbs. per sq. in. Maximum	Lbs. per sq. in. Minimum
4	1:1	47.3	56.2	39.7	1½:1	57.1	61.9	53.0	2:1	55.9	73.6	45.4
8		56.4	64.8	48.9		60.5	68.8	48.5		72.3	94.7	55.1
12		64.9	76.7	52.5		64.4	85.8	45.4		76.2	89.8	54.1
16		62.9	73.3	53.6		73 2	91.6	55.6		67.9	83.6	53.0
4	2½:1	54.9	62.5	43.8	3:1	49.9	65.6	40.9	3½:1	51.0	61.3	44.5
8		64.6	80.4	53.5		57.0	67.6	51.5		54.0	62.8	49.4
12		55.0	67.7	41.0		54.6	63.6	45.0		55.5	68.7	50.0
16		57.6	74.4	36.7		53.1	58.1	40.6		56.8	65.7	51.5
4	4:1	52.8	59.7	41.2	4½:1	47.6	55.4	38.8	5:1	64.1	75.4	52.5
8		53.8	57.0	50.0		49.6	53.0	44.5		68.1	74.5	65.0
12		52.2	58.7	45.4		54.4	58.0	48.5		63.7	69.3	57.0
16		49.6	58.6	43.0		48.7	52.0	43.0		65.8	72.5	59.0
4	5½:1	56.4	64.7	52.0	6:1	53.7	59.2	49.5				
8		56.7	62.0	51.5		52.5	54.5	50.5				
12		60.4	73.0	53.4		54.7	60.0	49.0				
16		50.4	59.4	41.0		47.8	55.0	31.3				

SLAKED IN 150 PER CENT. OF WATER

4	1:1	41.0	48.3	33.8	1½:1	47.1	49.9	36.1	2:1	45.0	53.2	38.0
8		40.9	48.9	37.0		47.6	64.6	36.1		46.9	56.7	40.4
12		45.8	55.3	34.0		50.8	59.8	40.4		52.1	68.3	39.0
16		47.6	55.7	39.2		57.5	74.5	40.8		62.0	81.6	51.5
4	2½:1	55.4	68.7	38.8	3:1	60:7	68.7	45.7	3½:1	71.9	81.0	61.8
8		59.8	78.1	44.4		54.0	64.5	47.5		60.7	71.4	41.4
12		56.6	76.3	42.8		63.7	72.1	51.0		76.2	84.1	69.7
16		55.4	79.9	51.0		77.3	83.0	66.3		76.3	83.4	64.3
4	4:1	60.5	67.7	53.5	4½:1	51.7	59.4	44.9	5:1	46.0	51.5	40.4
8		63.9	74.5	59.4		58.9	62.6	53.1		47.5	51.0	45.0
12		69.9	76.8	60.6		61.1	64.3	49.2		49.6	48.2	42.0
16		59.5	70.7	49.5		60.5	68.4	53.1		60.2	75.5	42.3

SLAKED IN 200 PER CENT. OF WATER

4	1:1	45.0	60.6	37.2	1½:1	44.4	58.3	35.7	2:1	45.2	54.6	38.5
8		45.5	62.8	44.3		51.0	65.6	43.9		57.3	69.7	45.9
12		45.2	61.8	42 6		40.0	57.1	34.7		50.6	61.2	40.0
16		47.4	53.1	41.2		48.5	67.0	36.4		53.4	62.8	46.5
4	2½:1	41.7	55.2	33.4	3:1	46.9	57.1	37.0	3½:1	46.2	53.1	38.0
8		51.2	69.8	38.8		55.0	72.4	43.9		56.0	67.0	46.5
12		50.9	61.8	37.4		49.6	65.9	42.3		55.2	59.2	52.0
16		60.6	68.0	53.1		54.0	58.2	48.4		57.5	60.8	52.1
4	4:1	40.6	44.9	38.0	4½:1	41.0	44.1	38.6	5:1	43.8	46.0	39.8
8		47.7	57.3	38.8		53.2	63.1	38.8		46.3	50.5	42.6
12		52.9	60.0	47.5		52.2	57.4	45.5		53.5	59.6	38.0
16		53.0	57.0	45.5		54.9	57.1	53.0		52.7	54.5	47.0

SLAKED IN 250 PER CENT. OF WATER

4	1:1	35.4	37.6	33.2	1½:1	38.9	40.9	33.0	2:1	37.9	41.0	33.0
8		43.2	49.0	36.0		45.4	53.2	35.4		48.6	56.1	44.1
12		38.0	43.9	35.0		41.2	46.4	36.8		47.4	55.5	42.8
16		40.0	45.2	36.0		43.9	50.0	36.5		51.8	58.9	42.0
4	2½:1	42.7	62.5	38.8	3:1	52.6	61.0	42.9	3½:1	52.7	60.0	43.4
8		50.1	60.2	36.5		54.8	63.6	41.0		48.5	55.1	40.4
12		51.9	63.9	40.4		56.8	70.6	45.2		56.3	63.3	46.0
16		58.9	70.8	46.4		58.7	69.0	50.0		58.0	62.0	57.0
4	4:1	43.2	64.0	35.0	4½:1	47.5	58.3	37.4	5:1	50.2	55.4	30.5
8		43.4	48.0	35.0		50.9	58.0	35.9		56.6	62.2	42.4
12		53.0	56.6	49.0		54.5	60.5	45.5		56.9	61.6	53.0
16		51.2	54.0	42.0								

SLAKED IN 800 PER CENT. OF WATER

4	1:1	38.1	47.4	25.5	1½:1	35.6	48.4	26.0	2:1	36.0	48.4	28.6
8		35.8	54.2	27.3		35.2	53.6	28.8		35.9	43.9	28.6
12		43.0	58.3	28.2		38.5	54.6	27.8		40.7	53.5	34.0
16		41.7	57.8	26.6		40.8	51.0	34.3		41.2	52.1	32.0
4	2½:1	41.8	50.0	35.3	3:1	40.0	50.5	32.6	3½:1	42.4	50.0	33.3
8		46.2	51.0	40.8		40.2	53.0	30.6		52.1	58.1	45.2
12		51.1	60.2	39.6		46.1	51.0	36.0		52.5	55.0	45.9
16		56.8	63.8	50.0		47.8	54.0	40.0		46.7	58.0	35.0
4	4:1	38.2	46.5	31.3	4½:1	39.7	43.5	32.8	5:1	40.7	47.5	35.0
8		39.2	51.5	31.9		45.8	55.5	38.2		48.3	54.9	42.7
12		37.6	43.5	28.8		43.6	48.5	35.9		46.3	52.0	43.0
16		43.0	50.5	40.0		41.4	49.0	30.7		46.1	53.0	30.0
4	5½:1	37.8	44.5	34.0	6:1	41.7	46.0	36.6				
8		46.7	52.9	38.6		46.5	51.3	41.5				
12		46.5	52.4	38.5		47.7	54.3	43.1				
16		46.5	58.0	43.2		49.8	55.0	44.3				

To be continued.

RAILWAY ROUNDHOUSES

BY R. A. NORMAN, B. M. E.

Unless one is connected in some way with railroad work, he seldom hears anything about the workings of the roundhouses of our steam railways. Should such a person take advantage of an opportunity to become acquainted with the purposes and doings of the roundhouse he would no doubt be surprised to learn of its real importance in the operation of a railway system.

The function of the roundhouse is, primarily, to supply an engine for the train department whenever it may call for one. Constant readiness to meet such a demand requires first class facilities for handling engines, plenty of good workmen and a person in charge who is a capable manager.

It will be at once appreciated that the roundhouse management is often severely exercised when called upon to have an engine ready for the train department at a definitely specified time. This is in part due to the fact that the facilities for handling engines are not generally up to the needs of the situation. The enormous weight and size of the modern locomotive, the heavy train that it is required to handle, and the speed it must maintain all demand frequent inspection of engines. Safety and good service as well require this and there must therefore necessarily be more or less repair work done at each end of the division or, in other words, each time the engine comes to the roundhouse.

Besides the repair work, there are other matters to which attention must be given that are even more important. Coal must be supplied to the engine, also sand, water and oil. The roundhouse serves as a distributing station for these materials and of course must always have an abundant supply on hand. This necessitates the maintenance of coal chutes, sand-house, water tanks and an oil house, the arrangement of which counts for much in the prompt handling of engines.

The first three of these buildings are usually located along the incoming track in the order named. As soon as the engine is turned over to the roundhouse force, it is first supplied with coal, then sand and water. It is next run to the clinker pit where the fire is knocked and the ash pan cleaned, after which the engine is ready for the house.

Most roundhouses, or engine houses as they are sometimes called, are built in the form of a circle, or a portion of one, although there are some that are rectangular in shape. The latter are however not very common. Owing to the rapid increase in the size and power of locomotive engines in recent years and the enormous increase in the volume of railway business, roundhouses built several years ago to meet the then existing conditions are today inadequate. The present conditions are, however, gradually being met by altering or reconstructing the old houses. Where the business appears to demand it, the new houses are so planned as to permit of extension and are equipped with the most modern devices for handling the locomotive and for doing all work known as 'running repairs.' The turn-table is located in the center of the circle and affords a means of turning the engine as well as placing it in any desired part of the house. The larger roundhouses are equipped with a drop pit which permits of the removal of driving and truck wheels in case there is a broken wheel or bad journal.

The roundhouse is also equipped with a machine and forge shop for doing the necessary repair work. All roundhouses are supplied with means for washing the locomotive boiler to which regular attention must be given since a dirty boiler affects detrimentally its steaming qualities besides being very injurious in other ways. The essentials of the equipment for this work are plenty of hot water and a force pump.

The foreman of a roundhouse has complete charge. His duties are of a varied nature, ranging from overseeing the work of skilled mechanics, machinists, boiler makers and carpenters, to handy-men, helpers, and the ordinary laborers. Besides these men, the foreman has charge of the engineers and fireman. Duties that cover such a wide range require that a foreman, to meet with success, must possess exceptional ability in the handling

of men and knowledge and good judgment in the care of engines.

The roundhouse foreman finds himself on the first rung of the ladder in the motive power department of a railroad. If he is successful in this capacity, his prospects for advancement are good. A position of this kind affords an excellent opportunity for gaining mechanical knowledge and the art of handling men.

The person who is not familiar with the purposes and duties of the roundhouse should spend a day in a plant of this kind. Twelve hours careful observation will render plain to him that more depends upon the care and attention which the locomotives receive than is generally believed; and that the condition of the engine contributes more largely than any other one factor to the prompt handling of trains and to efficient service.

ALUMNI

The following men, all '07 graduates in the Electrical Engineering course, entered the Westinghouse shops at East Pittsburg as apprentices: F. L. Tunis, J. F. Woods, W. F. Uhl, J. C. Clark, H. H. Henningson and C. J. Stahl. Mr. Woods and Mr. Stahl have been recently transferred to New Rochelle, N. Y., where they are assisting in the electrification of the New York, New Haven and Hartford Railway.

Mr. H. G. Semmons, B. S. in E. E., '07, Mr. E. A. Cameron, B. S. in E. E., '07, and Mr. H. V. Nye, B. S. in E. E., '05, are working for the Bullock Electric Mfg. Co., (Allis-Chalmers Co.) at Cincinnati, Ohio. Mr. Semmons states that there are about thirty-five graduates in the Cincinnati shops and that they are well treated by the company. He and Mr. Cameron have been in the Insulating Department and are now in the Induction Motor Winding Department.

F. V. Skelley, B. S. in E. E., '07, is taking the students' course at the Hawthorn Works of the Western Electric Co., Chicago. Mr. Skelley was given about three weeks work in the Brush Department, about six weeks in the Commutator Department and has now (November 1) been working for ten weeks in the Induction Motor Winding Department. He is much pleased with the treatment accorded him by the company and states that he can live comfortably on twenty cents an hour, at which rate the students are paid for the first year.

Messrs. M. O. Bolser and R. D. Whitacre, both B. S. in E. E., '07, are working for a Hydro-Electric Power Company in North Yakima, Washington. There appeared in a recent number of the Electrical World an interesting and well prepared article on "Magnetic Hysteresis Phenomena" by Mr. Bolser,

pointing out in a clear way the significance of some of the phenomena of varying magnetic flux.

Messrs. W. A. Danielson, J. A. Moorhead, L. J. Hicks, Gus Scherling, R. A. Grove, Ed. Soukup and Paul Whallon, all '07 graduates in Electrical Engineering, are in the student course of the General Electric Co., at Schenectady, N. Y.

M. G. Mather, '07, and W. G. Rubel, '06, are in the employ of the Washington Water & Power Company, Spokane. They are now engaged in the construction of a hydro-electric power plant to be connected with a 3-phase transmission line carrying 66,000 volts a distance of one hundred miles.

Announcements are received of the marriage of L. A. Wilson, B. C. E. '07, to Miss Ethyl Miller of Storm Lake, Iowa; and of W. R. Barber of the same class to Miss Eloise Coates of Ocheyedan. Both these gentlemen are engaged in drainage engineering with headquarters at Sibley, Iowa.

M. A. Mills, B. C. E. '07, is located at Kahlotus, Washington, where he is employed in railroad construction in a portion of the state where there is but little settlement.

H. M. Howard and Will Francis, both graduates in Civil Engineering, 1907, are employed by the Florida East Coast Railway Company.

H. G. Dimmitt, B. M. E. '03, has been recently promoted from the position of gang foreman in the C. M. & St. P. Ry. roundhouse at Savannah, Ill., to roundhouse foreman at Ottumwa Junction, Iowa, with a good increase in salary.

E. C. Macey, '96, is now in California where he is engaged in the location of some two hundred miles of railroad for the Stone & Webster Co., of Boston. Mr. Macey has but recently completed an electric railway line in Texas for the same company.

Mr. A. McKinnon of the class of 1894, Yalesville, Ct., was accidentally killed the latter part of September while engaged in his engineering work.

Mr. J. B. Marsh, '82, has the contract for the construction of the Locust Street bridge in Des Moines, Iowa. It is to be a reinforced concrete arch and one of the finest bridges in the city.

AT THE COLLEGE

The Interurban company which operates cars between Ames and the College are to build three covered concrete platforms at their principal stops on the campus: one at the Creamery, another at the Farm station and the third at the west gate. The platforms will be sixteen by seventy-six feet and steel posts will support the roof.

Plans have also been approved by the executive council for

the construction of a new depot for the electric line to be located north and west of Morrill Hall. The building will be twenty-six by thirty-eight and one-half feet, of buff brick and slate or clay tile roof, and will be entirely surrounded by a cement platform.

Plans are approved for a $10,000 improvement in the College water supply. A new electric centrifugal pump will draw the water from the wells already sunk north of the heating station into a 140,000 gallon concrete surface reservoir from which it will be lifted to the steel tank by a fire pump located in the new heating plant.

Grading is nearly completed for the switch from the interurban line to the heating plant. When the track is laid coal will be unloaded directly from the cars into the bins.

The main line of the heating tunnel from the central heating plant is completed nearly to the old motor depot. It was found necessary to remove the old depot platform as the line of the tunnel runs very close to the building which is itself to be razed and removed in the near future.

Among the flourishing societies at I. S. C. is the local branch of the American Institute of Electrical Engineers. The membership of this branch includes one member, ten associate members and thirty student members of the A. I. E. E. Meetings are held twice a month at which papers presented at the New York meetings of the Institute are abstracted and discussed. Original papers are also read.

On the evening of October 30, a very successful social meeting of the branch was held in the new Alumni-Y. M.-Y. W. C. A. building at which a short, non-technical program, interspersed with music, was given, followed by a luncheon and a number of interesting and humorous toasts by members of the faculty and several students.

CONVENTION DATES

The Iowa Brick and Tile Association will hold its 28th annual convention at Des Moines, January 22 and 23, 1908. The program is not yet made public. Particulars may be obtained from the secretary, C. B. Platt, Van Meter, Iowa.

THE IOWA ENGINEER is the official organ of the Brick and Tile Association and all important papers read at the convention will appear in this publication.

The fourth annual convention of the National Association of Cement Users will be held at Buffalo, January 20 to 25, 1908. The headquarters are to be at the Iroquois Hotel and the exhibits in the old 65th Regiment Armory, Broadway and Potter Streets.

The 22nd annual convention of the National Brick Manufac-

turers' Association meets this year at Columbus, Ohio, February 3 to 8, 1908. As affiliated organizations, the American Ceramic Society and the National Paving Brick Manufacturers' Association hold their meetings at the same time. The sessions of the A. C. S. will be held February 3, 4 and 5. Headquarters for the N. B. M. A. is the Southern Hotel, while the Hartman Hotel will be the place of assembly for the Ceramic Society. Particulars regarding these meetings may be obtained from Mr. T. A. Randall, Indianapolis, Ind.

The annual meeting of the National Association of the Manufacturers of Sand-Lime Products convenes at Columbus, Ohio, December 4, 5 and 6, 1907. H. de Joannis, of the Plymouth Building, Chicago, is the secretary.

The Cement Products Exhibition Co., recently organized among the cement manufacturers of the west, announces its first exposition to be held at the Coliseum in Chicago, December 17 to 21. Mr. L. L. Fest, New Southern Hotel, Chicago, is exposition manager.

The Canadian Clay Products Manufacturers' Association holds its 6th annual convention at Ottawa, November 19, 20 and 21, 1907.

The 30th annual meeting of the Illinois Clay Workers' Association will be held at Peoria, January 14, 15 and 16, 1908, with headquarters at the National Hotel. Geo. M. Hartwell, of the Clay Record, Chicago, is secretary.

According to "Brick" the 8th annual convention of the Wisconsin Clay Workers' Association will meet at Milwaukee, Wis., probably during March, 1908. The secretary is Oscar Wilson, of Menomonie, Wis.

The Iowa Association of Cement Users will hold its 4th annual session, February 19, 20 and 21, 1908, in Des Moines. The Savory Hotel will be headquarters and here space will be provided for both the meetings of the Association and the exhibits. Exhibitors may arranged for space by corresponding with either the secretary, Ira A. Williams, Ames, Iowa, or J. R. Hubbart, Mgr., Savory Hotel, Des Moines.

The March issue of the Iowa Engineer will contain the Proceedings of the Cement Users' Convention. All the important papers read are to be published with the accompanying discussions. Those interested in cement and its products may arrange for a copy of the March number by addressing the Iowa Engineer, Ames, Iowa.

INDEX TO VOLUME VII

STARRETT'S
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Straight Edge, 42-inch graduated, - - - $6.75
Bevel Arm, 15-in., with clasp and section liner, 7.50
Protractor, - - - - 5.00
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THIS COMBINATION OF TOOLS WILL BE FOUND TO BE A GREAT AID TO BETTER AND EASIER DRAUGHTING. The Straight Edge has needle carriers at each end, swinging on taper studs. These may be swung to bring the points close to the working edge, and by a slight turn of a knurled nut may be rigidly locked, holding the straight edge bradded to the paper. We make these straight edges in six lengths, from 18 to 48 inches and either plain or graduated.

The Bevel Arms, with clasp and section liner, are made in 15, 24 and 36-inch lengths, and may be used with our graduated T-squares as well as with the straight edges.

The Section Liner is in the form of a knuckle joint and feeds either way against the graduation marks. By thumb pressure on the button-headed screw, which may be adjusted to fine or coarse movement, hatching may be rapidly and neatly done, and for accurately spacing work to the scale of 1-16, 1-8 or 1-4 to the foot, the device is a great convenience.

The protractor is 1-4 of 14-inch circle and is graduated to quarter degrees. It accurately fits the the bevel arm either side up.

Further information with prices of the various sizes of these instruments, is given on pp. 162 et seq. of our Catalogue No. 17AC of Fine Mechanical Tools. The Catalogue is free.

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